REPRINTS

BY THE

ANTIQUARIAN AND SCIENTIFIC SOCIETY OF THE CENTRAL PROVINCES.

The papers on the Geology of the Nagpore Province, by the Rev. Messrs. S. Hislop and Hunter, have been selected for the 2nd Number of the Series of Reprints, as they contain information of interest to all residents in the Central Provinces.

These papers were originally published in the Journal of the Geological Society of London, and have now been reprinted from the Geological Papers on Western India edited by H. J. Carter, Esq., F.R.S., late of the Bombay Medical Establishment.

H. RIVETT-CARNAC,

Honorary Secretary to the Antiquarian and
Scientific Society of the Central Provinces.

Camp, September 1867.

7 7 23

PAPERS

ON THI.

GEOLOGY AND FOSSILS

OF THE NDIGHBOURTOOD OF

NAGPUR, CENTRAL INDIA.

BY

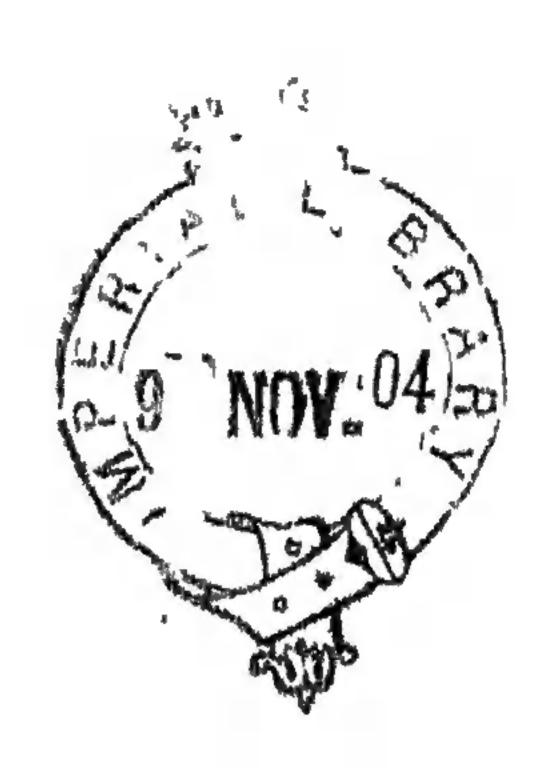
THÈ REV. MESSRS. S. HISLOP AND R. HUNTER.



Magpore:

REPRINTED BY THE ANTIQUARIAN AND SCIENTIFIC SOCIETY OF THE CENTRAL PROVINCES.

1867.



•

ON THE GEOLOGY AND FOSSILS OF THE NEIGHBOUR. HOOD OF NAGPUR, CENTRAL INDIA.

BY THE REV. MESSRS. S. HISLOP AND R. HUNTER.

PART I.

GEOLOGY OF THE DISTRICT.

CONTENTS.

Physical Geography of the District.

History of Geological Observations in the District.

General Geology of the District.

Extent of the trap-rocks.

granitic and schistose rocks, sandstone and shales. laterite &c.

Description of the strata.

I. Superficial formations.

1. Black soil or Regur.

2. Red soil.

II. Brown clay.

III. Laterite.

IV., V., VI. Upper and Lower Trap, and the enclosed sedimentary formation.

Fossils, and age of the enclosed freshwater deposit.

Extent of the freshwater deposit.

Minerals of the Trap.

Age of the Trap, and the mode of its cruption.

VII. Sandstone formation, and its four divisions, with their fossils.

Thickness of the strata.

Character of the formation, and its age.

VIII. Plutonic and metamorphic rocks.

Metals of these rocks.

Age of the crystalline rocks.

Conclusion.

Physical Geography of the District.—The country to which the following paper refers is the western part of the recently acquired kingdom of Nágpur,* lying, with the southern corner of the Ságar and Narbaddá territories, between 78° 15′ and 80° 35′ cast long., and 19° 35′ and 22° 40′ north lat. It is of a triangular shape, each side extending about 180 miles. Its northern side is formed by the table-land stretching from the Mahádowa hills on the north-west to the northern extremity of the Lánji hills on the north-east: the south-eastern side is constituted partly by the chain last mentioned, and

^{*} With regard to the spelling and pronunciation of Hindu names of places, the authors have furnished the following remarks in one of their late letters to the Assistant Secretary:—

[&]quot;Orthography in India is a very unsettled branch of learning. These who first stereotyped in English characters the Hindu names of places were most unsuited for the work, and hence most unscientific is the system of spelling practised by the generality of our countrymen. We follow the Jonesian system, as it is adopted by such societies as the Royal Asiatic. By that every Hindu letter has an English representative, though that representative has more a Continental than an English sound attached to it. The vowels are $a_i a_{i-1}, a_{i-1}, a_{i-2}, a_{i-1}, a_{i-2}, a_{i-1}, a_{i-2}, a_{i-2},$

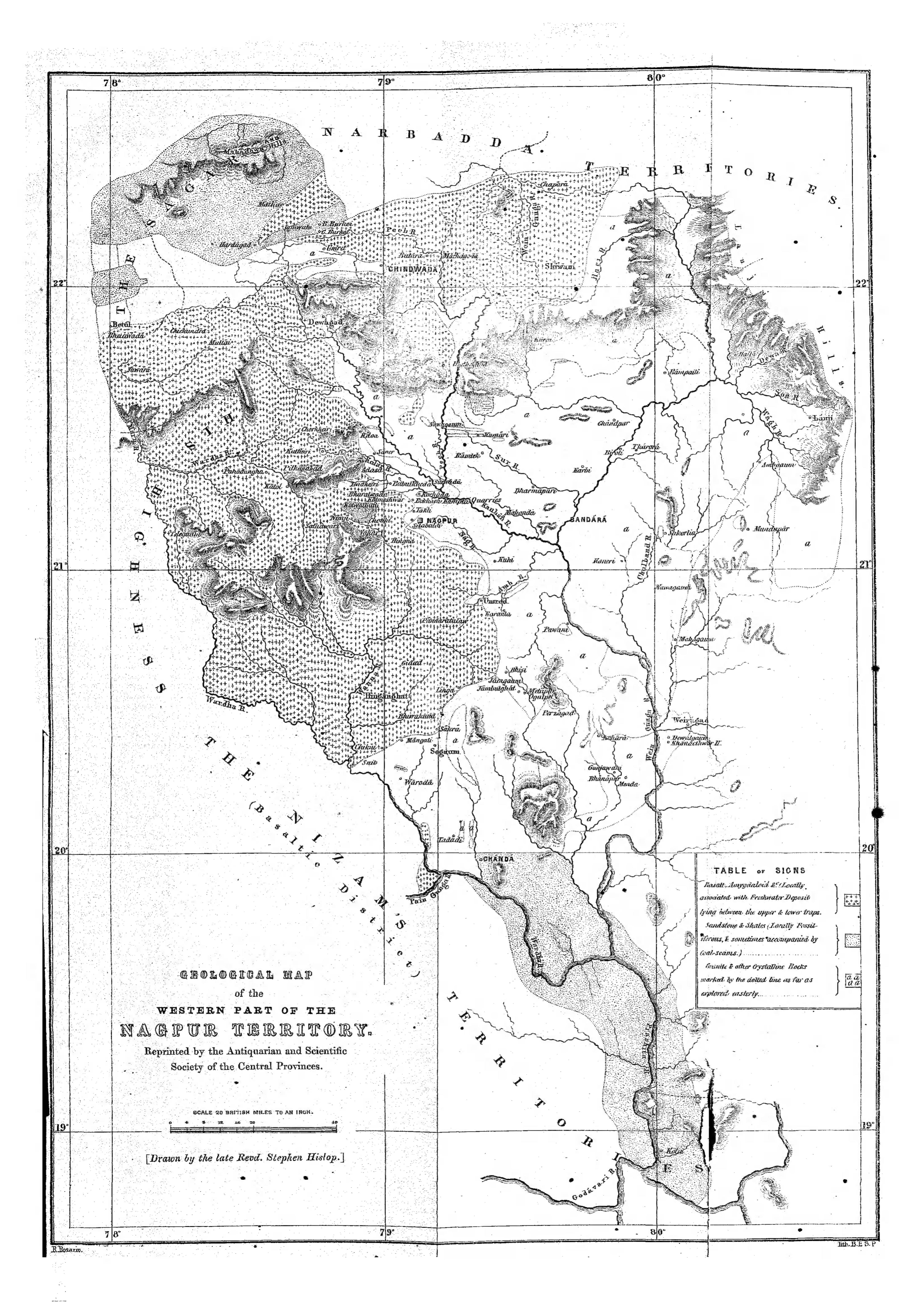
partly by a line drawn from its southern base to the junction of the Wein Gangá and Wardhá, which latter river marks out nearly the whole of the south-western side. (See Map.) The limits, as thus defined, enclose an area corresponding with that surveyed by Lieutenants Norris and Westen in 1826, and amounting by their calculation to 24,000 square miles.

The city of Nágpur is situated very near the centre of this area. In the northern division, where the hills are both most numerous and most elevated, the direction of the ranges is east and west. In the southern, which centains a greater extent of level country, the course they take is generally north and south.

Chouragad, the highest summit of the Mahadewa hills and the loftiest point in our district, rises to an altitude of 4,200 feet above the sea; the usual height of the range, which, entering the Nagpur territory from Gawilgad, passes by Dowagad towards Shiwani, is not above 2,000 feet, though in the east of the same chain, where it goes under the name of the Lánji hills, some of the peaks attain an elevation of 2,300 and 2,400 feet. At Nágpur the country has fallen to a level of 1,000 foet. On the west, however, it immediately rises by 200 or 300 feet in a succession of eminences, which run parallel to the Downgad range, until they reach the basin of the Wardha, when they suddonly sink in precipitous descents, as at Talogaum Ghát. Towards the east of the capital the plain extends almost without interruption to the banks of the Woin Gangá, where the general level is about 900 feet above the sea. Still further east, on crossing the river, we find the country proserving its former flatness, except that occasionally it is diversified by ranges of hills running north and south, of which that encircling the lake of Nawagaum is the most considerable. In the southern division of the territory there are few hills, if any, that rise above 2,000 feet; while the champaign tracts, which abound on both sides of the Woin Gangá and Wardha, fall, ere these rivers have effected the junction of their united streams with the Godávari, to 800 hundred feet above the sea level.

It will thus be seen that our district presents a watershed from north to south. The most important rivers which flow through it are

being just the same sound more dwelt on; i the sound of English e, made long or short as it has accent or no accent. There is only one consonant that may occasion difficulty, that is a d written in talies. When so written or printed it is intended to have a sound somewhat like r. Thus we write Weinégad, whereas it is commonly written Wyraghur. The gh for g is just a gross mistake, which destroys the etymology of the language to a person who does not know the original Hindu name. Silewada, as written by us, is usually represented Sillewara."





the Kanhán from the Mahádewa Hills, which at Kámpti receives the Pech from the same upland tract, and the Kolár,—the Wardhá, which is joined by the Wanná from the hills west of Nágpur, and by the Pain Gangá from the Nizam's country,—and the Wein Gangá, the largest of all, which on its left bank is increased by the united streams of the Wágh, the Son, and the Dewa, and by the Chulband, and on the right by the Kanhán and Wardhá, after its confluence with the latter of which it takes the name of the Pranhíta, and ere long discharges its waters into the Godávari.

History of the Geological Observations of the District.—The geological structure of the territory, whose extent and natural features have been thus briefly described, has for some time engaged the attention of scientific men in India. Dr. Voysey and Captain (now Colonel) Jonkins were the first who examined it. From the result of their investigations, as published in the Bengal Asiatic Society's Transactions, Part I. for 1829, it would seem that they were unsuccessful in their search for fossils. The lamented Voysey, indeed, who was the first in India to find shells in a stratum enclosed in trap, thought he had discovered, on the journey hence to Calcutta, which terminated his distinguished career, bivalves in a bed of limestone noar Rayopur, within the Nágpur State, though on the east of our district;* but I have since ascertained that the appearances which he regarded as organic are the consequence of the peculiar concretionary structure of the rock. The next observer within our field of investigation was Dr. Malcolmson, who in 1833, worthily following up Voysey's discoverios within the Nizam's dominions in 1819 and 1823, pointed out new localities for the formation in the same part of the country, and traced it into this kingdom to Chikni and Hinganghát. At the former of these places which is sixty miles south of the city of Nágpur, he mot with Unio Deccanensis, Physa Prinsevii, Paludina Deccanensis, and Melania quadrilineata: at the latter, which is sixteen miles noarer the capital, he found an abundance of silicified wood. But, though he lived in this neighbourhood for some years, he does not appear to have been aware of the existence of similar organic remains here; and while, with Voysey and

^{*} Beng. As. Soc. Journ., vol. xiii., p. 856.

[†] The arst person singular here refers to Mr. Hislop, by whom the memoir is for the most part written, with the exception of the description of the plants and insects of the tertiary deposits, which is from the pen of his fellow-labourer Mr. Hunter. For a previous notice of the "Geology of the Nágpur State," by the Rev. S. Hislop, son Journ. Bombay Asiat. Soc. No. 18, July 1853, p. 58 &c.—H. J. Carter.

Jenkins, he calarged on the mineralogy of Sitabaldi Hill, like them he failed to advert to the two rocks which are its most interesting features—his own traff-imbedded stratum with Physas and Melanias towards the top, and an unfossiliferous member of the sandstone formation resting on gneiss at the bottom. In 1842 Lieutenant Munro, of H. M.'s 39th Regt., brought to light in the sandstone quarries near Kampti, nine miles NE. of Nagpur, the impressions of forms, which were forwarded to Malcolmson as having previously discovered the first vegetable remains in the sandstone of the Hyderabad country, by whom they were figured and described as resembling Glossopteris Dancoides of Royle.* As this species of form is now understood to be a Tamioptaris, it seems likely that the comparison of the Kampti specimens with it was incorrect, and that they belonged to a Glossopteris whose species, owing to the fragmentary state of the fronds, cannot be determined.

In 1815 I procured a few fessils of the same kind from the Khmpti sandstone, and two years subsquently my esteemed colleague the Rev. R. Hunter and myself fell in with them in the contemporaneous strata of Chándá, eighty miles south of Nágpur. None of these specimens, however, were preserved, nor was anything further done by us or by others to understand the palmentology of this part of India, until June 1851, when, walking with my follow-labourer in the neighbourhood of our residence, two or three Physas, in a deposit enclosed in trap hill about a mile west of Sitábaldi, and two miles in the same direction from Nágpur, forced thomselves en my notice. They were at once referred to the fessils which Voysey and Malcolmson had discovered in a similar situation, and the deposit in which they occur was identified with the freshwater formation that they had traced in several parts of the Nizam's territory, and at Chikni and Hinganghat, in this State. In a fow days after, at the same spot, I found the first bone, and Mr. Hunter the first tooth; and, after a week or two, on Takli Plain, about 2½ miles NW. of Nagpur, I met with the first fruit and Entomostracan. About the same time, from observing the traces of ancient vegetation on the soft clayey sandstone, used, in the absence of chalk, for whitening the writing boards in our Mission schools, I was led to make inquiries about the locality from which it was brought, which ended in the discovery of Glossopteris and, Phyllotheca and some seeds or seed-vessels at Bhokará, six miles north of Nagpur. Ere long we were joined by our friend Captain Wapsharo, Judgo Advocate of the Nagpur Subsidiary

^{*} Bomb. Br. R. As. Journ., vol. i, p. 249.

Force, who added many valuable regetable remains to our collection; and it is to his able and generous efforts that we own, among other rare acquisitions, the first palm and the first mulberry-like fruits. From the red shale of Kerhádi, seven miles north of Nágpur, I procured tracks of Annelids, and more recently, in combination with thom, the footmarks of some reptile: and towards the end of the year, in contpany with Lieutenant Sankey of the Madras Engineers, I visited Silowada, twelve miles north of Nagpur, where the sandstone yielded a ropusion of rich and most boautiful specimens of Glossopteris, and whence have since been obtained a variety of exogenous stoms, several species of Phyllotheca, and an interesting specimen, contributed by Mr. Hunter, of an allied genus, which by Lindley and Mutton is reckened an Equisetum, and by Bunbury probably an Asterophyllites.* A Mission tour, undertaken about the same time, conducted my colleague and mysolf past the freshwater formation at Páhádsingha, forty miles WN W. of Nagpur, in which was detected an abundance of fish-scales dispersed through the stone. On our return, Mr. Hunter, among the seeds and fruits of Takli, discovered the first specimen and the greater part of our fossil Coleoptera; while we received an accession to our collection of shells from Dr. J. Miller, thon of the 10th Rogt. M.N.I., who, while on an excursion with Dr. Fitzgerald, had found the freshwater formation at Butará, near Machhagodá, eighty miles north of Nágpur, and also from Mr. Sankoy, who had fallon in with it at Pilkápahád, twenty-five miles to the north-west. The latter-named officer, after discovering in the Kampti quarries the first Vertebraria, a fine species of Phyllotheca, a long endogenous leaf, and an abundant kind of seed, all of which he liberally handed over to us, proceeded, along with Dr. Jordon, the Indian ornithologist, in the direction of Butará and the Mahadowa hills, * whonce they returned with several new fossils bolonging to our Eastern coal-formation, and excellent specimons of the sholls previously collected by Dr. Millor, agreeing in general with those of this neighbourhood. In a portion of the Butará rock which they kindly gave me, I was struck with the appearance of a diminutive creature, which proved to be a second genus of the Ento-' mostraca. Ere the first anniversary of the discovery of our earliest Physa had come round, several other localities had been ascertained for both the freshwater and sandstone fessus, and observations had been made on the remains of quadrupeds and shells imbedded in com-

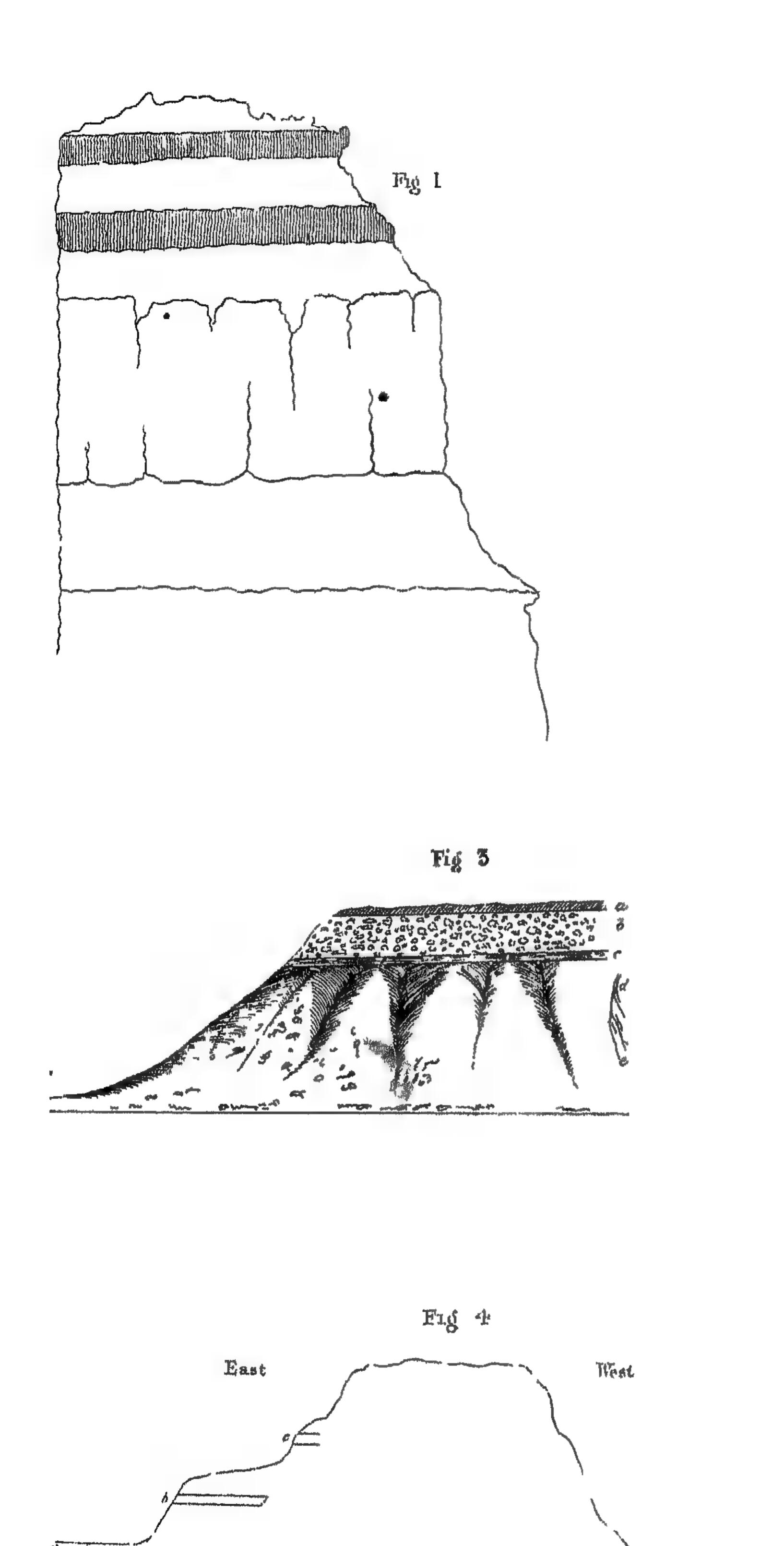
^{*} Quart, Journ. Geol. Soc., vol. vil., p. 189. † Ibid., vol. x., p. 55.

paratively recent deposits. Since that, on our annual Mission tours, we have become acquainted with a productive site for sandstone or ganisms at Mángali, sixty miles south of Nágpur, which has afforded few unusual vegetable remains, a species of *Estheria*, scales and jaws of fish, and the entire head of a saurian; we have passed through districts abounding in laterite and iron ore, and have increased our knowledge of the geological structure of the country generally.

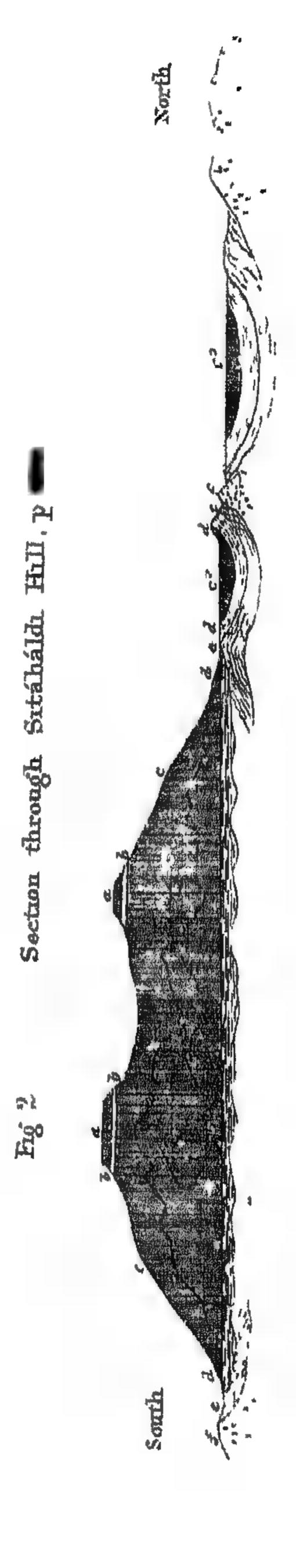
General Geology of the District .- From the rapid survey which we have taken in the proceding historical introduction of the fossils that have been brought to light within our area, it is obvious that its palæontology, contrary to the common idea of Indian formations, is both varied and important; but even in a lithological point of view there are few tracts of equal extent that are worthy of more attention; and of all the portions of that interesting area there is none for interest that can be compared with the vicinity of Nágpur,—its centre at once political, historical, and goological. We have only to take a few stops from our house and we reach the summit of Sitábaldi Hill, the scene of as heroic a conflict as ever our countrymen gained in the East. The spot on which we stand consists of nodular trap.* At the distance of a few yards from our feet, just under the brow of the hill, is a narrow stripe of green or yellow calcarcous indurated clay, which on close inspection is found to contain a number of decaying casts of freshwater shells. Under this we perceive a bluish-green friable rock, which hardens first into a tough amygdaloid, and then, a little above the level of the plain, down to which it is scarped by the quarrymen, into a compact greenstone. Cropping out from under the foot of the hill may be seen a bed of soft variogated sandstone, and then, according as we look east or west, the prevalling rock covering the plain beyond is either gneiss or trap.

But let us extend the prospect to the horizon. As we stand with our faces to the north, the first glance that we cast on the distant hills shows that there is a marked difference among them. Behind us, on our left, and in front, we follow a long sweep of flattened summits, with here and there a valley to break the uniformity; but no sconer do we look towards the right than we descry a series of round-topped hills rising

^{*} Plate VI., fig. 2—Section through Sitaballi Hill.—a, Overlying nedular trap 1 b, Freshwater tertiary; c, Underlying trap, vesicular for some feet, under the freshwater deposit, then compact, but nedular at the sides; d, Highest member of the sandstone series, which most probably underlies the amygdaloid throughout; c, Gneiss, into which much of the sandstone has been transformed; f, Pegmatite.



Reprinted by the Antiquarian and Scientific Society of the Central Provinces



up at intervals in massive strength. These flattened summits are the tops of trap hills, which stretch, in the form we see, from our present position to the coast of the Arabian Sea; and these massive eminences are granitic hills which rise up in the manner that meets our eye, at various distances from each other, from the place where we stand to the Bay of Bengal. The intermediate hills and plains, which in front fill up the foreground, are formed of the dolomite and shale of Korhádi, and the sandstone of the basins of the Kanhán and Kolár.

From our clevated station we are thus enable to command a prospect of twenty miles in every direction, and the formations that we can trace within that range make up an exact miniature of the goology of our whole area. Nay, were we to go down the hill and walk around its base, in the descent and circuit, which might all be accomplished in twenty minutes, we should meet with almost every rock that is to be found between Bombay and Katták.

The geology of our area must at one time have been extremely simple. Its principal feature was then sandstone, associated with shale and limostone. But now other two formations are discovered on the arena, and these scem on the surface as if they had been two huge icobergs which approached each other in frightful collision, crushing the sandstone between them, and allowing the fragments to slide out at oither end, and scattering them here over their own bulk. Or, to speak in language more precise, the sandstone formation, which once occupied the whole space that we have chosen for description, is now covered up by trap on the west, and broken up by granite on the east, leaving only a small diagonal stripe running through the centro, which, after being interrupted at the north-west and south-east, increases in these directions to broad expanse, while a few detached portions formerly continuous with it appear in the body of the trap and granite. It is the juxtaposition of trap, sandstone, and granite in this neighbourhood which invests the geology of Nágpur with special importance, and which, when investigated by competent observors, may shed I flood of light some future day upon Indian goology in general.

Trap Rocks of the District.—The greater part of the trap within our area lies in the west in the shape of parallelogram, one of whose corners has been encroached on by projecting portion of Borar and the Betul district of the Ságar and Narbaddá territories. Its greatest length is 120 miles, and its breadth is from 50 to 60. Its south-western side, on which the irregularity of figure is found, and by which it joins

on to the great sheet of basalt in the Dakhan, is formed by the Wardha. Its south-eastern side, commencing from Suit, on that river, crosses the road from Nágpur to Chándá, on the south of Chikni, and, passing by the north of the Mángali fossiliferous quarry, extends to Sákrá and Bhiwákund, after which it coincides very nearly with the political division between the Súbás (provinces) of Nágpur and Chándá, which stretches by Lingá, Jámgaum, and Alasur hills to the north-west of Bhísi. Here begins its north-east side, which skirts the small patches of sandstone on the west of Umred and Kuhi, and running close by the city of Nágpur meets with an eruption of granite, and then touches the sandstone basin of the Kanháu and Kolár, after which it again encounters plutonic rocks on its passage up the right bank of the Kanhán to Dewagad. At this ancient Gond fortress the upland tract of Multái, which constitutes the north-west side, joins that last described, and completes the parallelogram.

In addition to this, the main body of trap within our area, and connected with it, there is a smaller development of the same formation in the north. Stretching south and east from Dewagad, it fills up the space between the Kanhán and the Pech, and, sweeping westward round the granite at Chindwádá, and eastward by way of the summit of Kurai Ghát to Shiwani and Chapárá, it merges, along with the Mathur range of hills, in the basaltic district that extends to the Narbaddá at Jabbalpur.

The above is, I believe, all the overlying trap within our area, with the exception of one or two isolated portions south-east from Suit, near Waroda.

Granitic and Schistose Rocks.—The plutonic and matamorphic formation the extent of which I shall now briefly indicate hies chiefly in the castern portion of our area. It is intersected by the Wein Gangá for the greater part of its course. The tract on the left bank of the river I have had little opportunity of exploring; but, from the cursory examination I have given it, I have reason to believe that there is a large development of granite and its allied rocks, including an extensive outburst of perphyry, which coincides nearly with the upper portion of the course of the Wagh river. This eruption exhibits crystals of quartz, and of white (occasionally red) felspar imbedded in a dark pasts of the same ingredients. On the right bank of the Wein Gangá, in the districts near its junction with the Wardhá, the extent of the formation is not so great. It is observed principally in the channel of the Wein Gangá, though it may also be traced around the bases of the sandstone chains of hills

which it has been the means of upheaving. In both the districts under consideration the general strike of the strata is N. and S., corresponding with the direction of the streams and mountain ranges, and in that last mentioned the dip is for the most part to the west. But it is on the north that the greatost development of granite and crystallino schists occurs. There we may perceive these rocks rising to the surface (though it would be hazardous to conclude that there are not others of a different character in the hollows covered up by the deep soil) from Nágpur northeastward to the Lánji hills,—a distance equal to the length of our trappean parallelogram, and with a breadth in proportion. This second parallelogram is applied perpondicularly, but unequally, to that previously described. Near the line of contact, i.e., in the district near Nagpur, the gnoiss and other metamorphic rocks, like the hills and tributaries of the Wein Gangá which run through it, have uniformly an oast and west direction, with voins of the massive rock ponotraling them at right angles to the strike.

This is the case with the crystalline formation north of the Kámpti quarries, which has communeated to the sandstone strata there and at Silewádá a southerly dip. As the granitic cruption, however, is traced up the basin of the Kanhán, it is seen to bend round a little, and to give a westerly inclination to the sandstone at Bábulkheda, Tendakheiri, and Adassá. From the lastmentioned place it proceeds northwards past Sáner and Kelod, in a narrow stripe on both sides of the Kanhán up to Dewagad. Beyond this we find it rising up around Chindwidh, and running west to Betul. But returning to the neighbourhood of Nágpur we discover, parallel to the great body of the granitic formation on the north of Kámpti, a range of quartz hills running in the line of the strata westward from Waregaum to Guntárá. The plutonic force, which has tilted up these, has greatly disturbed the limestone rocks at Korhádi, and given to the sandstone at Bhokárá, on the south of the Kolár, the same dip as we observe at Silewádá and Kámpti on the north of that river.

Sandstone.—But let us now refer to the sandstone formation, which L-have said exists in the central parts of our area, though only the wreck of what it once was. Its upper member, reduced in thickness by metamorphic agency, may be observed horizontally entering the trap hill of Sitábaldi on the east side, and again emerging on the west. It is then wholly displaced by gueiss and granite towards the Nagriver, after which it again becomes the surface rock for a short distance to the west, until it is a second time overlaid by trap. It remains thus concealed for sixteen miles, when it is seen on the north-west of Yahar

at Nimji, whence it extends to Satuawari on the south-west and Kotwálbadi on the north-west. At these villages it is a third time covered up by trap, nor does it in that direction rise again to the surface within our area, or indeed, I believe, anywhere boyond it. The division of this formation, which proceeds to the north of Nagpur, occupies a part of the basins of the Kanhan and Kolar from Kampti on the south-east to Kelod on the north-west, being about thirty miles long and twelve broad. Its north-eastern border touches the great granitic tract which stretches from Nagpur to the Lanji hills, while its south-western boundary is constituted by the trap, surrounded by which three of its detached portions are found at Kutkheiri, Chorkheiri, and Chicholi, near the source of the Kolár. Were we to follow the direction of these outliers, they would lead us to the sandstone hills boyond our area that skirt the southern side of the trap chain of Gáwilgad, north of Elichpur. But if we suppose the sandstone continued north-west in the line of the Kanhan's course, we arrive, after crossing some miles of trap and granite, at the beds of carbonaccous and clayey shales, which, running under the trap range of Mathur, appear on the north side, and form the base of the lefty development of sandstone at the Mahadowas. The largest body of this formation, however, lies to the S. in the basin of the Wardha and Pranhita, extending, from the termination of the basaltic offusion at Jungaum Hill and Suit south-east towards Badráchellam in the Godávari, with only a few outliers of trap, as before mentioned, near Waroda, some slight intrusions of plutonic rocks at Segaum and the west of Chandá, and a prolongation of the granitic series of the Wein Ganga basin, which runs south by Daba as far as Dowalmari, and reappears from under sandstone at the mouth of the Indrawati in connection with an extensive outcrop of schistose strata terminating at Tekalágudam.

A very marked feature in the geology of the country between the Iri and the Wein Gangá is the occurrence of ranges of sandstone hills running for the most part north and south, corresponding in general direction with ranges of the same formation in the district of Kotá, described by Dr. Bell.* These hills, where they have fallon under my observation, rise from plains of plutonic rocks, by which the strata have been indurated and elevated, though still retaining the horizontal position. Such is the flat-topped chain which stretches on the east of Segaum, and that which terminates in the castle-like bluff of Porzágad.

Quar. Journ. Geol. Soc, vol. viii., p. 230.

On either side of the Wein Gangá we meet with some isolated remnants of the sandstone formation. One of these, but very limited in its dimensions, lies on the banks of the Selári, a small stream which joins the Wein Gangá near the town of Pawani. Another, for ther down the river, extends for some distance, first on the right bank and then on the left. In the district on the east of the Wein Gangá a little sandstone proper is met with, in patches among the hills on the west bank of the Gárwi and Wágh rivers, reaching from Mahágaum as far north as Ambgaum.

Inderite &c.—In various parts of our area we meet with heds of laterite, covering the rocks already described. I have not found it on the west of Nágpur; but it is seen abundantly within the trap district at Ságar, N. of Dudhgaum, and at Pándarataláw, SW. of Umred. At Karanlá, E. of the same town, it overlies plutonic rocks, and from Pawani, on the Wein Ganga, it stretches in a broad belt, sometimes ever sandstone and at other times over gneiss and granite, towards Weiragad. South and west of this throughout all the province of Chauda it occurs more or less. I have already mentioned the fact of its resting on dolomite at Ambájiri. At Máhonda, on the Kanhán, straight cast from Nágpur,—at Dharmapuri and Karbi, in the basin of the Súr River, which flows from Rámtek into the Woin Ganga,—and again in the neighbourhood of Chándpur, further up the Wein Ganga, the same formation is presented to view. But it is on the east bank of the river that its most extensive development is witnessed. Crossing the Rayopur road at several places, it unites on the north of it to form extensive tracts in the district of Lánji, and all around Hattá and Kámtá.

The superficial deposits that are superior to laterite are either red or black. The former is found in general where plutonic rocks, sandstone, or laterite prevail, though instances are not rare of the latter being met with in such situations. The "rogur," or black soil, occurs almost universally where trap abounds.

Description of the Strata.—Having thus given some account of the extent of the formations within our area, as they appear on the surface, I shall now endeavour to point out in a descending order their thickness, nature, contents, fossil or mineral as the case may be, and age.

Superficial Formations.

1. Black Soil or Regur.—The regurk is of no great depth in this

In Memoir on the "Geology of the Nagpur State" submitted by me to the Rembay Br. R. Asiatic Society in March 1853, and published in their Journal for July of that year, I made some remarks on the origin of the regar. Dissenting both from Voysey's theory of its arising from the decomposition of trap, and Newbold's view of its deposition in the

district, seldom if ever exceeding 20 feet. In some places, as at 'likli village, it is seen to overlie stratum of brown tenacious clay which, like itself, is much mixed with "Kunker." I have not succeeded in finding any organic mains in the regur, except bones of exen and shoop of very doubtful antiquity.

2. Red Soil.—The red soil in our area is of greater depth than the black, frequently displaying a section of 50 feet. Tike it, it seems to rest on a brown calcareous clay, at the bottom of which there is in goneral a layer of conglomerate. In river-basins it alternates with layers of loose sand and gravol, ofton imbedding existing fluviable shells of the genera Melania, Corbicula, and Unio. In the district west of Nagpur the rivers often expose a bed of sand and gravel comented by a small quantity of lime, and in its consolidated state furnishing blocks of sandstone or conglomorate two or three foot thick. This stratum for the most part is unfossiliferous, but near the Kolár, about ton miles north of Nagpur, there occurs in it an abundance of Paludina, Melania, and Corbicula, which, though belonging to existing species, from the nature of the matrix have been much altered since the period of their deposition. Of some the cavities are simply filled with siliceous and calcareous matter, but in the greater number of instances the shell has been completely absorbed, and employed as a coment in aggregating the particles of the rock. A similar doposit is soon at Nagalwada, near Elichpur, to the west of our area; but there, in addition to the fessils just mentioned, it includes Limneus, Planorbis, and Unio. On the banks of the Sarpan rivor, near Tondákhoiri, fourteon milos NW. of Nagpur,

I anggested, from the analogy of the Telermoisem, the probability of its being a subabinal formation that had taken place in marshy situations, where, of course, vegetation would be abundant. As this suggestion has been misunderstood, I may here take occasion to explain it. I never supposed that there was no clay on the surface while the regur was being formed. There is clay in the Russian soil, with which it was compared. What I intended to say was, that while there was a basis of both silica and alumina (the debies not of trap exclusively, but of any rocks in the neighbourhood capable of yielding them), this basis existed in a locality characterised by the excess of its moisture and the rankness of its vegetation, to which two circumstances, and not to the nature of the original debus, was due the colour of this colebrated soil. That these causes are adequate to the effect will, I think, be admitted. Stagnant water, may be seen in cosspecie, always communicates blackness to its sediment; and the grass and other plants that would downsh in the circumstances which we have supposed would tend materially to the same result. To account for appearances of stratification in the logur, it may suffice to remark that I take for granted that rains, and all the other influences which rearrange and commingle the soil of the Dakhan at present were at work in former times. The depth of the cetten soil is somewhat overstaied in the toxt. Ton feet is its greatest throkness even in Bornr, where we may look for its most typical features. There also it is underlain by brown tenacious clay that would rotain the moisture on the surface

there is an accumulation of the freshwater shells previously enumerated, with considerable intermixture of a species of Bithinia, and a few specimens of land shells—Helix and Bulimus. Mingled with these remains of Mollusca there was a quantity of jaws, vertebræ, and other portions of Mammalia, which were not much petrified; but, I regret to say, they were accidentally destroyed before they could be examined.* In the bank of the Kanhán at Kámpti, about 45 feet under the general surface, I found the shoulder-bone of some mammifer, much increased in weight from the process of petrifaction. Bones in the same state have been discovered lying above ground between Nágpur and Kámpti, which must have been washed out of the kunkeracoous red soil.

Judging from the relation of the regur and red soil to the brown clay, I am inclined to regard these two formations as contemporaneous; and, from the evidence of the fossils contained in the latter, I would class both as Post Pliocene.

II. The Brown Clay, on which I have said both the red and black superficial deposits rest, averages, together with its underlying conglomerate, a depth of 20 feet. The clay is not known to be fossiliferous, but in Takli Plain there were found, in the conglomerate, apparently the tasks of a large mammal, which had been completely converted into stone, but they were so much affected by the weather as to fall to pieces on being removed. The formation containing them I suppose should be assigned to the Newer Pliecene, and will rank with similar deposits at Jabbalpur and elsewhere.

III. Laterite.—This formation seldom exceeds 10 foot in depth anywhere in our area. No fossils have yet been discovered in it here, but diamond mines have been opened in it east of Nágpur. Malcolmson,* and after him Newbold, inferred the identity of the sandstone of Central with that of Southern India from the existence of diamonds at Weirágad, a town about eighty miles SE, of the capital. The inference, however, is drawn from erroneous premises, which would have been corrected had these authors personally visited the spot. At Weirágad there is no sandstone near the diamond mines; the only rock in the vicinity is quartzose and metamorphic. It has been too much

Some fragmentary bones, from the banks of the Sarpan, imbedded in a sandyearth, and associated with numbers of Melama, Paludma, and Unio, form part of the series of organic remains forwarded by Mossrs. Hislop and Hunter. The bones, having been kindly examined by Professor Owen, prove to have belonged to Ruminants of two sizes,—such as a buffalu and small satelope—Ed. Quar. Geol. Soc. Lond.

Bomb. Br. R. As. Soc. Jones, vol. i, p. 250.

taken for granted, in my opinion, that the diamond conglomerate of Southern India is connected with the sandstone, within tracts of which it is sometimes found; and hence the arenaceous strata of the peninsula have actually come to be designated by the name of diamond sandstone. Now although the diamond conglomerate has been found reposing on sandstone beds, yet there is no instance, that I am aware of, of the diamond having been extracted from any one of them, nor are there any data to prove that the conglemerate derived most of its materials from that source. On the contrary, Heyne's has shown that the pebbles at Kondápetta and Ovalampallia, near Kaddápá, are chiefly of chert and jasper, basalt, quarter, hornblende, and felspar. The first two have evidently been derived from the limestone of the neighbourhood, and the rest from ignoous rocks. And these pobbles are not contained in a pasto of sand, but, according to lleyne, of clay. It is true the diamond conglomerate may in one place overlie sandstone; but in another place, as at Kondápetta, it may rest upon limostone, while in a third, as at Bejwádá, near Másulipatam, according to the statement of Captain Newbold, it may be found immediately above gneiss ! In short, I am inclined to concur in the verdict long ago pronounced by that experienced Indian observer Dr. Heyne, when he remarked, "All the diamond mines which I have seen can be considorod as nothing else than alluvial soil" (superficial deposit). But if the matrix of the diamond be a surface deposit everlying several recks, I can perceive no propriety in attaching its name to one of these more than another. The matrix at Weiragad is a lateritic grit, and it is worthy of notice that wherever the precious gem is sought for, whether in India or Brazil, there for the most part oxide of iron is diffused.

Having myself mot with no fossil in this formation, I have nothing to offer by way of determining its precise age, but would content myself with remarking that it must be posterior to the overlying trap, on which it is found occasionally, though in our district very rarely, to rest.

IV., V., & VI. Trap and its enclosed Sedimentary Formation.—The next rock to laterite in the order of downward succession is the overlying trap, with which, however, for the sake of perspicuity, it will be necessary to combine the freshwater formation previously alluded to, and the underlying trap.

Trap, it was before stated, is the prevailing formation in the west of our area; but when that assertion was made it was understood that this

^{*} Tracts on India, p. 97. † Ibid, pp. 96 and 105.

[‡] R. As. Soc. Journ, vol. viii, p. 245.

volcanic rock is of two kinds,—one overlying and the other underlying; and that between these two, and therefore solden exposed to view, there is for the most 'part found an aqueous deposit. All three generally occur together. The exceptions are met with in the plains on the outskirts of the trap formation, where we not unfrequently observe the usually enclosed stratum resting immediately on sandstone, without the presence of either the upper or lower basalt. In some of these instances it is probable that the overlying rock has been removed, and cases occur of its remaining where no underlying trap has ever existed. On the other hand, there are examples in similar border localities of a single sheet of trap extending over sandstone without being associated with a second sodimentary formation or volcanic effusion.

Though the three formations are generally connected with each other, yet it is chiefly the upper one, viz., the everlying trap, that meets the eye over the face of the country. Leaving out of consideration the very few examples of donudation which have uncovered the freshwater deposit in the plains, and the equally rare instances of eruption which have there upheaved it on its edge, it is on the escarpments of the table-lands that we may be said to gain our whole knowledge of this department of Nágpur geology. In commoncing our ascent of those steep hills our attention is attracted by a number of blocks near the foot, which are easily distinguished from the masses of basalt among which they have fallen from all above. As we make our way up ever the hard, dark, vesicular rock, the blocks increase in number, until we come to a friable greyish or bluish-green zone. We must now move slowly and look narrowly, for a few yards of upward progress may conduct us from the soft amygdaloid, where fragments are thickly strewed, to a nodular basalt, where not a trace of them is to be seen. Occasionally the freshwater formation is so thin that a very little earth or herbage may suffice to hide it from our sight. But generally the water from the brow of the hill in the monsoon collects into little rills just at the place *where it leaves the nodular trap, and having now gathered enough of strength to make an impression on intervening barriers, it proceeds to plough up the soft deposit, and the still softer subjacent amygdaloid, leaving an interval between each streamlet, like talus resting on the hander vesicular rock bolow (see fig. 3).* The thickness of the overlying trap on Sitabaldi Hill and the tabulated summits in its immediate

Pl. vi., Ag. 3:—Sectronal View of one of the Trap Hills near Nagrur.—a, Surface soil; b, Nochilar trap (15 to 20 feet thick); c, Freshwater deposit; d, Soft amygdaloid; c, Hard amygdaloid.

vicinity is from 15 to 20 feet, which agrees very exactly with the thickness assigned to it by Dr. Voysey at Jillan. On the Western Gháts, however, according to Colonel Sykos, a stratum of earthy jusper, which is just our freshwater doposit, was found near Junar under a thickness of from 300 to 600 feet of basalt.* But it not unfrequently happons that in leaving the plain and climbing up a trappean hill we may come upon the freshwater deposit at three distinct elevations. There is, first, the stratum which underlies the nodular trap genterally throughout the plain, and which may be seen sometimes laid bare at the commencement of the ascent; thon, after passing over hard and soft amygdaloid, we come to another bed, overlaid by nedular trap; on gaining the top of this we reach a terrace, which conducts us to another ascent, where we find, ere mounting to the summit, a repetition of amygdaloid, sedimentary rock, and globular basalt. An example of this occurs at the hill of Gidad, forty miles S. from Núgpur, the top of which has been appropriated by the disciples of m Musalmán saint named Shok Faríd, to a mendicant establishment, which is supported by the donations of Hindus and Muhammadans alike, from all parts of the Nágpur territory. See the accompanying section of the hill from east to west (fig. 4), where a is the deposit in the plain, white; b, the stratum of a rod colour under the terrace; and c, a ropotition of it higher up, brownish green. Whether there was a fourth stratum above r, the quantity of brushwood, and want of time, prevented me from observing. That all these strata are one and the same, though they differ in hue, I have no doubt. When we become acquainted with the changoablenes of this deposit within space of a few yards, its different phases on the eastern declivity of Gidad Hill occasion no difficulty. Noar Katol, forty miles NW. from Nágpur, a similar appearance is presented. There a thick stratum of red clay lies at the foot of the hill, and we see its tendency to slope upwards and loan against the ascent; but we leave it behind, and come upon the amygdaloid, which emorgos from under it. The amygdaloid is overlaid by a bod of rod clay, which is surmounted by nodular trap constituting a terraco. Above this, before we reach the submmit, we most with a succession of amygdaloid, rod clay, and nodular trap

^{*} Trans. Gook Soc., 2nd Ser., vol. iv., p. 419 [and p. 100 of Papers on the Goology of Western India edited by Mr. Carter].

[†] Pl. vi., fig. 4 — Section of Grand Mill.—a, Freshwater deposit, as seen in the plain, of a white colour; b, Freshwater deposit of red colour under the terrace, c, Freshwater deposit higher up, brownish green in colour.

again. In ascending the Ghát to Gáwilgad Fort, which, however, is beyond the limits of our map, the same thing may be observed. The slope is so steep that the road is carried in winding direction up its face, and, although there are no terraces, yet, if I remember right, the traveller comes upon our deposit, which is there of deep red clay as at Kátol, three or four times successively.

From the remarks now made it will be inferred that the stratum in question is extremely varied. Not only is it of all colours and all mixtures of tints, but it is of all kinds of substance and all forms of structure. At one place it is calcareous, at another siliceous, at a third clayey, and at a fourth a compound of all three. Here it is soft, and there indurated; frequently the upper layer, which is next the everlying trap, is hardened, while the lower part remains unchanged. Here it is crystalline, there cherty, and elsewhere scoriaceous. In one spot it is full of fossils, in another neighbouring locality it is utterly devoid of all traces of ancient life. In one part of a hill we see it six feet thick, but as we follow its line along the face of the escarpment we may witness its reduction to little more than an inch. I know not one constant feature that is characteristic of it. In judging of its identity, a very usoful guide to follow is its position between the nodular trap above and the vesicular trap below; but even this, as we have seen, fails us on the outskirts of the formation. Extensive experience, that enables us to combine several criterions that would singly be insufficient, is here, as in so many other cases, the only sure help towards arriving at a correct decision.

The greatest depth of the underlying trap, from its lower part being generally concealed, it is impossible to ascertain. It is obvious that according to its greater or less development the plain rises into a gentle swell or increases to the dimensions of a hill. Near Takli, at the spot where almost all the fruits have been discovered, it is only a few inches thick, and a few yards from that locality it thins out altogether; whereas at Sitabaldi Hill, where it is observed to rest on sandstone, it attains a thickness of 100 feet; and in hills where its superposition on the sedimentary rock cannot be seen it must be a great deal thicker.

I have been thus minute on the appearances exhibited by the overlying and underlying trap, and the deposit enclosed by them, in order that we may have a clear idea of their relation to each other. The conclusions to be derived from my description I need scarcely indicate. It is quite evident that, before either of the volcanic rocks was poured

out in our area, there had been deposited on the sandstone - stratum which must have been at least six feet thick. Over this there was spread a molten mass of lava, which hardoned the surface of the stratum, and itself cooled into a flat sheet of globular basalt about 20 feet thick. After a period of repose the internal fires again become active and discharge another offusion, which insulates itself between the sandstone and the superior deposit; and, accumulating in some parts, more than in others, through force of tension, ruptures the superincumbent mass, tilting up the stratum and scattering the overlying trap, or, raising both stratum and trap above the lovel of the plain, either leaves it a flat-topped hill, or, with boiling surge, pushes up its summit gradually or by fitful offort. In these convulsions the more recent trap, where it has not tilted up the deposit altogether, has generally encroached upon it, entangling some of its fragments, con-* verting the greater portion of it into a crumbling vesicular rock, or producing miniature outliers of amygdaloid from materials susceptible of the change.

[Fossils.—As the detailed description of the fossils of the tertiary formation and of the older sandstone series will form the subject of Part II. of this memoir, and be published hereafter, the fossils of the freshwater deposit are here merely referred to in short.

From the collections made by Messes. Hislop and Hunter and their friends from this deposit,* the authors mention the following organic remains:—

Small bones, probably reptilian.

Remains of a froshwater tortoise.

Fish-scales, both Cycloid and Ganoid, in great numbers.

Insects, found at Takli: Mr. Hunter enumerates about ten species of Coleoptera.

Entomostracans; five or six species of Cypris.

Mollusca, land and freshwater, in great numbers. The following genera are enumerated:—

Bulimus.† Molania, Limmous.
Succinea. Paludina. Unio.
Physa. Valvata.

An extensive series of organic remains and of fock specimens from the superficial deposits, the tertiary beds, the fossiliferous sandstone and shales, and from the crystalline tooks, has been presented to the Society by the author of this memoir. The fossils, however, have not yet been fully worked out.—Illo. Quart. Journ. Gool. Soc. Lond.

Plant-remains: Mr. Hunter enumerates-

Fruits and seeds, about fifty species.

Leaves, exogenous, six forms.

,, endogenous, three or four.

Stems, exogenous, few species; some specimens six feet in girth.

,, endogenous.

Roots, six or seven kinds.

Chara, seed-vessels.

In concluding his notice of the tertiary insects and plants, Mr. IIun-ter observes—

"Before quitting this part of the subject, it may be observed that it would not be difficult to concoive with some degree of accuracy the nature of the locality in which the fruits grew. Going buck to the tertiary epoch, we find Tákli part of a lake extensive enough to be bounded at least on the west and south, and probably on all sides, by the horizon. We assume rather than can demonstrate the existence of islands which break the uniformity of the sea-like expanse of waters. On the higher land of these are forests, mainly of exogenous trees, some approaching six feet in girth. More scattered, but yet sufficiently numerous to attract notice, are palms, exhibiting on their stems, when closely examined, protuberances of acrial roots, similar to those so frequently observed on the Wild Date of India. In the more shady valleys are leguminous and other plants, in great variety and profusion and there may be seen occasionally climbing by numerous tendrils over the bushes, - cucurbitaceous plant allied to the Luffa, its tonder stalk weighed down by a ponderous and probably ten-angled fruit. The Nipadites here and there fringes the marshy shores; and whorever the water is shallow there rise above it the reedy poduncles of Aroid plants, terminated at one season of the year by spikes of flowers, and at another either by long succulent purple fruit, resombling mulberries, or by large pericarps, that without minute examination might be mistaken for cones.]

Age of the Freshwater Deposit.—It has already been shown by my esteemed colleague, in his concluding observation on the tertiary plants (see above), that the body of water in which the strata containing the above-enumerated fossils were deposited must have been a lake. I shall now inquire at what period that lake existed. The determination of this question is attended with posuliar difficulties. In a temperate climate like Britain, the discovery of a large number of organisms fitted for a tropical abode at once demonstrates that the rock in which they

occur cannot have been doposited subsquently to a remote tertiary period. Here, however, where we have a tropical heat at the present day, the evidence derived from such a source is much more equivocal.

Still I think there are sufficient dissimilarities between our recent and fossil floras to prove the great antiquity of the latter. While there is a general resemblance between the two, inasmuch as Hedysarece, Cassid, Luffa, and Nipa are comprehended in both, there may be remarked, on the other hand, the total extinction of two genera, if not an order, of endogonous plants, that once flourished luxuriantly here,— I refer to the Mulberry-like and strobiliform fruits, which, though formerly so abundant, have at present no representative either in India or, so far as I know, throughout the world. We must therefore direct our thoughts to some period comparatively remote, when there was greater uniformity of temperature over all parts of the earth. Of the more ancient tortiary floras none corresponds with ours so well as that of the London Clay of Sheppey and Bolgium. In both of these localities we find Nipadites, and in the former also the Xylinosprionites and Tricarpellites of Bowerbank, fruits apparently allied to those found at Nagpur.

Of all the animal remains we have collected, scarcely one seems to be identical with forms now existing on the surface of the globe. The nearost approximation to specific identity is in one of the Cyprides, and in the minute discoid Valvata; but whother the identity is complete I am not competent to say. Supposing, however, that it were proved to be so, this fact would morely show that of all the living tribes inhabiting the waters or the margin of our old-world lake, not one has survived in India except a single species of Oypris; for the Valvata minuta is not now found here, nor indeed does any species of that genus appear to occur throughout Asia. But with these most diminutive exceptions, if exceptions they are to be called, the statement holds good that between our ancient and our modern fauna the agreement is not closer than generic. In the class of fishes the resemblance even to that extent is true only of one order,—the Cycloidans while the other order, the Ganoidans, which have left their horny and bony scales so abundantly in our rocks, have entirely disappeared from our rivers and tanks. Of the class Mollusca, while the general Planerbis and Ampullaria, now so common in our pools, are altogether absent from this deposit, Valvata Physa, so extensively represented in it, both in species and individuals, have disappeared from the plains of Central and Southern India. Of the six genera Melania, Paludina, Limnours,



Bulimus, Succinea, and Unio, which are common to both ancient and modern India, the differences between the recent and fossil species, specially in the Paludina and Limnaus, are very great. Of the former we have nothing at all so large as the P. Bengalensis of the East, or even the P. vivipara of Britain. In the latter genus none of our species appear to have belonged to the inflated type, but they are generally more on the model of the L. glaber than that of the L. stagnalis of our native country.

Combining, then, these facts, on the one hand we have the total dissimilarity between every species of our ancient and modern plants,—the disappearance from our flora of several genera, if not of something higher—the difference in prevailing type between some of our fossil and existing genera of molluscs, and the removal of others entirely from our continents to regious most remote,—and lastly, a still more decided transference among the orders of our fishes,-data which all point to the negative conclusion that it is no newer tertiary that can be compared with our freshwater deposit. On the other hand, we find generically, specifically, and individually an equality, to say the least, between our Ganoid and Cycloid fishes, and a resemblance between our flora and that of the London clay,-proofs which, in my opinion, lead us on to the positive inforence that among older tertiaries the eccene formation is that with which our freshwater doposit must be classed. Bronn, I perceive, assigned it to the era of the continental molasse. Whether or not the statements above made will be sufficient to show that this view is incorrect, it is not for me to say; at all events the fossils which we have contributed will enable others to decide.

Extent of the Freshwater Formation.—The extent of this tertiary freshwater formation throughout India is very great. In Captain Sherwill's recently published Geological Map we find it laid down on the west of Rajmahal, on the Ganges. Following the same parallel of latitude, we come to Rae, near Narwar, about forty miles south of Gwaliur, whence specimens of Physa were obtained by Mr. Frasor, formerly Agent to the Governor General in the Sagar and Narbadda territories. At Sagar itself organic remains were first discovered by Colonel Sleeman, afterwards described by Dr. Spry, and more recently investigated by Captain W. T. Nicholls of the 24th Regt. M. N. I. East of Jabbalpur, in the same territories, occur the sites Suleya, where Dr. Spilsbury procured Physa in 1833, Dhunra, in the same vicinity, Narayanpur, near Schajpur, Mandla, and Phulsagar, on the north bank

of the Narbadda, and m far up the river as Mohtura and Domadadar, in the Rámgad Rájá's country, at all of which localities the same indefatigable and successful geologist found shells, including an abundance of Physa, several specimens of Unio, and, if I may judge from the figures, of Limnaus and Valvata. None of them, however, are named.* North of the Narbaddá, near Mándu, univalve and bivalve shells abound in the marks and earthy limestone, as we learn from Captain Dangerfield, who styles them "Buccinum and a species of Mussel"+ (Physa and Unio?). Leaving the Narbaddá and coming to the Tapti, near its source, we find that Voysey, as has been mentioned by Malcolmson, in his memoir on this deposit, discovered shells, which he named "Conus and Voluta" (two forms of Physa?), at Jirpa and Jillan. which lie apparently on the north of the Gawilgad range. On the S. of the same chain of hills, near Elichpur, are Muktágirí and Bairám, whence Dr. Bradley procured the excellent specimens of Physa and Unio which I had the pleasure of sending to the Geological Society. Returning to Jirpa, we enter the district of Betul, about 100 miles NW. of Nagpur, which was explored by Captain Ouseley, who found shells at Chichundra and Murkha, on the E. of the town, at Bharkawada, Bheiawada, and Jawara on the S., and at Badori, Kolgaum, Gaikhan, and Bakur, on the SW. Passing over the localities within the State of Nagpur, to which sufficient reference has been made in the previous part of this paper, we arrive at the district north of Hyderabad, where, I am informed by friend, Physos have been extracted from one of the banks of the Godávari at Nándur, and where also fessils were discovored near Hatnúr and Manúr by Malcolmson, and at Medkondá, Shiwalingapa, and Deglur by Voysey, who as early as 1819, when organic remains were almost unknown in India, met at these localities with shells, including, - he thought, "Turbo, Cyclostoma, Buccinum, Helix, and Turritella," some of which may be identified as Physa and Valvuta. Not far from Deglur, on the S. side of the Manjará, Captain Newbold obtained specimens of Physa at Munapilli, I and again from between Kulkonda and Digái, on the banks of the Bhima, he was presented with specimens of Paludina Deccanensis by Captain

Bengal As Soc. Journ, vol. vni., p. 708.

[†] Physæ and smaller univalves are common at Jam Ghát, midway between Mhow and Mundlesar.

Malcolm's Central India, vol. ii., p. 829.

[§] Trans. Geol Soc., 2nd Ser., vol. v., pp. 570, 571.

Bengal As. Soc. Journ., vol. ziii., p. 987.

Wyndham. These are all * the fossiliferous localities for our tertiary formation with which I have become acquainted, with the exception of Bombay, and Pangadi near Rajamandri, afterwards to be moro particularly noticed. But besides these there are many places where the same deposit occurs destitute of organic remains. For example, my friend Mr. Hunter and myself, on a Mission tour, traced it almost without interruption from the vicinity of Nagpur, whore the lessils cease, westward to Elichpur, a distance of 100 miles and upwards; and while the material of the rock was sometimes a whitish lime, and at others a green or a red clay, we were uniformly unsuccessful in finding in it any kind of fossils. Similar differences are exhibited in the unfossiliferous stratum around Shiwani. At Garhákotá, near Ságar, thence to Tendukheda, on the Narbadda, wherever Major Franklin met with trap he "always found it in association with carthy limestone." + The experience of Captain Dangerfield regarding its position was somewhat different, he having met with it in cortain parts of Málwá, as "a thin bed of loose marl, or coarse earthy limestone," "near the bottom of the small hills and banks of the rivulets." The country between the Wardha and the trap region described by Colonol Sykos has not been examined by any geologist, so that no site can be named in it for our lacustrine formation except Jálná; but I remember noticing it on my first arrival in India, nine years ago, at many localities, though I have now forgotton their names. But whon we come to the scene of Colonel Sykes's efficient labours & we can trace it almost everywhere, under the name either of "ferruginous clay" or "pulvorulout limostone." The stratum of "red ochreous rock," varying in thickness from an inch to many feet, and in texture from friable to compact earthy jasper, occurs at Nandur and Jihar, near Ahmodnagar; at Kothul; in the scarps of the hill fort of Harichandargad, and a mountain near Junir; and at Sirur, Wangi, and Barloni, between which two lastmentioned places the bed is bolieved to be continuous. Finally, it occurs abundantly on the Ghats, frequently discolouring the rivulots, and giving a forruginous character to the soil over a considerable area.

I have since read of the discovery of a gyrogonite in a white aluminous shale, which was cut through for the railway between Madras and Bangalore. Wishing to learn who ther this chariferous deposit was of the same ago as ones, I wrote to the author of the announcement referred to, but received no reply. If it is contemporaneous, this will carry our terbiary formation 200 miles further south than any locality at present known.

[†] As. Res., vol. xviii., pl. i., p. 88.

¹ Malcolmi voliti, p. 828.

S Geol. Trans., 2nd Ser., vol. iv.

Cool. Trans., 2nd Ser., vol. iv., p. 419.

Pulverulent limestone is generally found in layers, varying from an inch to three feet in thickness, and covered by few feet of black earth. Examples of it are met with at Jihur and Islampur, near Ahmednagar; at Karkamb and at Salsee, ton miles S. of the fortress of Karmali.* Crystalline limestone, which occurs as an imbedded mineral in amygdaloid,† and "great masses of mesotype,"‡ which are found in similar position, seem to me, if I may judge from the analogy of the district of Nágpur, to be instances of our formation somewhat transformed. The ochreous rock or ferruginous clay above mentioned was discovered by Newbold at Sindaghi, in the Southern Marátha Country, which lies south of Colonel Sykes's district, and it was described by him as "finely laminated bright red bole," from three to six feet thick. And this is most probably the origin of the "red clay," which Newbold on analysis found to be the basis of the amygdaloid in which zeolitic crystals abound.¶

The strata of Bombay have been described in an able and luminous manner by Mr. H. J. Carter, of the Bombay Medical Service. In thickness they greatly surpass anything we meet with in Central India, reaching to between 40 and 50 feet, and they are peculiar in having a little carbonaceous matter covering some of the vegetable remains. The fossils themselves, however, whether animal or vegetable, bear a remarkable resemblance to those which have been brought to light at Nágpur. Thus we find among them freshwater tortoise,—the elytra of insects,—an abundance of Oyprides, one species of which appears to correspond with the O. cylindrica (Sow.), first found by Malcolmson,—a few indistinct impressions of shells like Melania,—fruits and seeds, though not of the same genera as ours,—ensiform endogenous leaves, like the Nágpur specimens,—corniform roots, which differ from ours only in being larger,—and an abundance of dicotyledonous wood.

At Pangadi or Peda Pangadi, noar Rajamandri, not far from the mouth of the Godavari, there are found some outlying trap hills, which General Cullen pointed out to Dr. Benza as fossiliferous. That gentleman visited the place, and decribed one of the ominences as consisting at its base of sandstone, which is overaid by amygdaloid veined with

^{*} Ibid, p. 420.

[#] Ibid., p. 421.

Tbid., p. 85.

⁺ Thid., p. 425.

Royal As. Soc. Journ, vol. ix., p. 38.

Bom. Br. R. As. Journ., vol. 1v.

jasper, then a limestone deposit with fessils, and finally a shoot of basalt. The fossils were stated by Dr. Bonza to be partly marine and partly freshwater; but as his statement was made at " time when not much attention was paid to the distinction between these two classes of shells, it was supposed that it might be incorrect. I confess that I myself was guilty of this wrong to the memory of an able geologist. However, I took stops to discover the truth, and through my friend Lieutenant Stoddart, employed in connection with the Godávari public works, I have ascertained, I am happy to say, that Dr. Benza is substantially right. His oysters were real oysters, though his "Ampullarie" most probably belonged to some species of Physa. "On only one of these hills," says my intelligent informant, "could I find any oysters; but there, I must say, they were as plentiful - stones." At the foot of a hill opposite to this, Mr. Stoddart found several kinds of shells, and among them a Physa identical with a species common around Nagpur which was in the same block with a *Ohemnitzia*. Thoro seems to be a great variety of molluscous remains at this locality, and it would well deserve a longor invostigation than my kind friend was able to give it.*

Here, then, we have the best proof which similarity of position and specific ddentity of contained fossils can afford, that the doposit enclosed in trap at Pangadi is properly contemporaneous with our freshwater deposit in Central India, although a majority of its organisms are truly marine. It is evident that it was here our great collection of frosli water, stretching, either in one continuous shoet or interruptedly, a disstanges of 1,050 miles, in a direct line from Rajmahal to Bombay, and of "660 miles from N. to the neighbourhood of Pangadi, discharged itself by an estuary into the sea. Whether this great expanse of fresh water was one or many lakes cannot now be determined, in consequence of the disappearance of trap from many situations where once it must have existed; but I am persuaded that the more careful the exploration made in the great basaltic region of Western India, the more evident It will become that the intervals between the lakes, if any there were, must have been exceedingly small. This was the conviction left onmy mind by travelling from Nágpur to Elichpur, and this I think will be

^{*}A small series of fessils from Pangadi sent by the authors comprises Ostrea, Cardium, Venus, Cheminitaia, and Nerinaa?—En. Quart. Journ. Gool. Soc. Lond.

More recently I have been favoured with a sight of the fessils from Kateru, two miles N. of Rajamandhi, presented by W. Elliot, Esq., to the Bengal Asiatic and Madras Central Museums. They include two species of Cardita, four of Certhium, and Monoceros or Pseudoliva; but none of them appear to agree with a species at present found in our Indian Seas.—S. II.

the feeling produced in the mind of any one, by taking a glance on map at any district, like Colonol Sykos's, that has been surveyed, even without reference to a lacustrine deposit.

Minerals in the Trap.—I ought now to describe the minerals contained in our overlying and underlying trap; but this has been so well done by Voysey, in his remarks on the structure of Sitábaldi Hıll,* that it is unnecessary. One of the most common in the locality just named, though elsewhere rare, is a pitchy black substance, with slee-like bloom upon it, lining the amygdaloidal cavities. This Voysey appears to have called "conchoidal augite:" my friend Mr. Carter supposes it obsidian. It occurs in bands lying one above another, which may be followed to a great distance in a horizontal direction. The intermediate spaces seem as if they had been successive effluxes of volcanic matter running along beneath the freshwater deposit, and then under one another, each offlux being united or welded to the preceding one by a vesicular bolt. Many of the minerals that are met with in the amygdaloid are derived from the tertiary strata. This is particularly the case with jasper, the veins of which, as may be learned from Benza's description of Padpangali Hill, and, as we perceive in numerous places in this vicinity, are situated just at the zone of the vesicular trap's intrusion on the superior deposit. Sometimes, instead of being jaspidified, the entangled parts of the strata are converted into chert, at other times they are crystallised into penderous masses of mesetype. In one locality the calcareous matter is diffused - strings all through the amygdaloid, forming seams of kunker, like those represented by Newbold; in another they are scarcely enclosed within its substance, but remain in blocks at the lower part of the deposit, which are compact externally, but in the interior, where the heat has continued longest, are found to be an aggregation of crystals.

On the plain south of Gidad hill there is, lying about, great abundance of spherical nodules, which on being broken up exhibit a structure radiating from a central point, so that they have been mistaken for Alcyonites. The fakirs, who have located themselves on the top of the eminence, have adroitly taken advantage of this natural phenomenon to exalt the name of the saint whose disciples they profess to be. These nodules, according to them, are so many fruits and spices of different sorts, which Shok Farid converted into stone, the largest having once been coccanuts, the middle-sized betelnuts (Areca), and

^{*} As. Res., vol. xviil, p. 128.

[†] Royal As. Soc. Journ , vol. ix., p. 88.

‡ Journ. Ben. As. Soc., vol. ix., p. 625.

the smallest nutmegs. There is a resemblance of the nodules to the last two natural productions; but, as all alike display an acicular crystallisation, it is difficult to trace the similarity of the largest to the fruit of the cocoa. Much light must be introduced into this land before the inhabitants shall be convinced of the falsehood of the alleged miracle, and shall be able to understand that the seeming organisms are simple zeolitic concretions that have issued from the soft subjacent rock. Nodules of the same shape are found in the same formation at Sonegaum, near Kalmeshwar, fifteen miles NW. of Nágpur, but, being purely calcareous, their interior consists of a confused mass of rhombic crystals.

The Age of the Trap.—Beginning with the more recent, as we have done in regard to the stratified rocks, we find that the amygdaloid or underlying trap has not only invaded the tertiary formation, but broken it up, and along with it the nodular basalt by which it is capped. The amygdaloid eruption, then, is incontestably subsequent to the basaltic. But what age is to be assigned to the latter? It is evidently posterior to the freshwater beds on which it rests. We have thus an overlying effusion of nodular basalt, which has taken place after the tertiary strata, and an underlying intrusion of amygdaloidal trap, which has occurred after the basaltic effusion. Besides these two formations of trap I know of no others in Central India, either more modern or more ancient. Captain (now Colonel) Grant, in his paper on the Goology of Cutch,* and Mr. Carter, in his memoir on the Geology of Bombay before quoted, have adduced ample proofs to show that in the districts which they have examined, there have been cruptions of volcanic matter subsequent to the amygdaloid; but in all the districts through which my colleague and myself have been called to travol no trap formation so modern has fallen under our observation. Nor has any more ancient than the overlying trap been discovered. It might be thought, from the occurrence of isolated pieces of trap in the lower part of our freshwater strata, that while these were being deposited there were sheets of volcanic rock already on the surface of Central India. But it appears to me that there are no such fragments whose existonce may not be accounted for on the principle explained by Lycll in his Manual, 4th edition, p. 446, and stated in a precoding page of this paper. Besides, at Bhokala and some parts of Takli Plain, where the amygdaloid has not been intercalated under our tortiary formation at all, but where the latter, with its characteristic fossils, rosts immediately

Trans Geol. Soc., 2nd Ser., vol. v.

and conformably on the sandstone, there is not a trace of volcanic matter to be seen. I am inclined, therefore, to doubt the occurrence of any trap in Central India older than our lacustrine deposit. In the southern portion of the Rájmahál hills M'Clolland* informs us that amygdaloid is found underlying the coal strata of that district. The coal there is manifestly the usual so-called oblitic coal of India, and therefore we have amygdaloid disturbing the jurassic formation. But, if a stranger to the locality may be allowed to express an opinion, I would respectfully submit that the position of the amygdaloid is not conclusive against its comparatively modern origin. It is obvious that the most recent age attributable to an intruded rock, such as it is, cannot be exactly determined by observing what strata it has disturbed in one district; for it may have invaded an older formation in one locality and yet, rising higher, it may have broken in upon a newer formation in another place; or, applying the principle to the case in hand, the very same amygdaloid which M'Clelland calls secondary trap, because it has been erupted among the colitic strata of Rajmahal, may be tertiary trap here, if it is, as I believe, the identical effusion which has been intercalated between the odlitic and tertiary formations of Nagpur. But for the conclusive determination of this question the district of Rájmahál, with a tertiary formation found in connection with trap in its northern part, and jurassic strata associated with trap in its southern part, prosonts the most belitting aroua.

Mode of its Eruption.—Before leaving the volcanic rocks it is desirable to indicate the lessons which Central India teaches as to the manner in which they were formed. Now, the first thing which strikes any observer of the great basaltic field of this country is the comparative absence of all cones or crators throughout. I cannot name a spot in all the tract with which I am acquainted where I could say either the nedular basalt or the amygdaloid came from below. The nodular basalt seems to have flowed along for immense distances, filling up the tertiary lake and leaving an arid plain in its rear. Then the amygdaloid, insorting itself between the sandstone and the freshwater bed, seems to have flowed generally underground on the same scale of grandour. Sítábaldi Hill, which is almost an outlier of the great basaltic region of Western India, being connected with it by a very narrow neck, would be a favourable place for ascertaining whether the underlying trap which has there accumulated under the tertiary deposit to a considerable thickness, has been forced up vertically through the gneiss and sandstone,

^{*} Report Geol. Survey of India, Season 1848-49. Calcutta, 1850.

which appear around the base of the hill to be inferior to it, or whether it has been horizontally intercalated, as in the generality of places between the sandstone and the tertiary. I am disposed to take latter view; but, if the Government quarry were only excavated a few feet lower, as Voysey long ago suggested, it would put an end to all doubt.*

From the statements previously advanced regarding the trappeau rocks of Nagpur, taken in connection with the same formation in other parts of the country, it is obvious there is no foundation whatever for the supposition that the great outpouring of basalt in India took place in the ocean. And, although I believe that the fresh water in which is really was effused must have stretched over great areas without much interruption, yet the discovery in the tertiary strata of abundance of pulmoniferous molluscs, such as Limnœus and Physa,—of plants, such as marsh or shallow-loving Endogens, buried with their roots and fruits almost entire, and therefore not far from the spot where they originally grew, -not to mention the occurrence of an amphibious univalve like Succinea, and of land-shells like Bulimus, together with great quantities of seeds and fruit and timber, the spoils of the neighbouring dry land—plainly shows that the water in that part of the lake was of no great depth. Indeed it seems obvious that in places not a few the water of the lake must have been so shallow to allow the ignoous rock which was poured out over its bottom to rise above its surface into the atmosphere. We must resert, then, to some other hypothesis than aqueous pressure to explain to horizontalness of our trappoan hill-tops, and a cause adequate to the effect is the well-known law by which the surface of liquid bodies is reduced to the same uniform lovel. To this law volcanic matter is subject in spreading over an area either of land or water. If to this it be objected that then we should expect the surface of the effusion to appear scoriaceous like modern lavas, it may be replied that naturally all such light materials in the lapse of ages would be worn away.

VII. The Sandstone Formation.

Under the amygdaloid, or, where it has not been intercalated, immediately under the tertiary freshwater strata, is found an extensive series of rocks consisting chiefly of arenaceous bods.

A. The upper member of this series is seen at the foot of Sitabaldi Hill, passing into gnoiss, into which much of it, as well as most

It has since been ascertained that the sandstone underlies the lower trap about the middle of the hill, and it may be warrantably supposed to do so throughout.—S. H.

probably all the lower members, have been converted. Without enumerating all its localities, I may mention that - good section of it is presented by a rivulet skirting the Lál Bág, where the layer under the nodular trap has itself been rendered distinctly nodular. It may be observed in the western division of the city of Nagpur; and it stretches in some places under the amydgdaloid, in others under the tertiary bed, but for the most part up the surface-rock, through Takli Plain to Bhokára. At Nágpur and in Tákli Plain the strata are of friable sand intermixed with kunker, and variegated with a deep irony-red and occasionally a purple colour. But it is at Bhokara where we can understand it best. In one of the quarries there we find it as at Nagpur, only with less of the colouring matter. Going northward to another quarry, we see it on the way overlaid by the lacustrine formation before described, which is capped by a small rise of nodular trap. Arrived at the quarry, which is only about 100 yards from the first, we find the same upper member of the sandstone, now, however, no longer soft and crumbling, but so hard that the hand millstones of the country, which resemble Scottish querns, are derived from it; and the ferruginous matter, instead of being diffused as blotches, is gathered into waving iron bands more indurated still. At this place those upper beds, which are about 25 feet thick and very coarse, contain angular fragments of a finer sandstone which lies below. Noar Bázárgaum the strata, where exposed, are pierced with irregular holes, which seem to have been caused by the action of rain and the atmosphere. At Kámpti, situated towards their top, and rising oven to the surface through the soil, are imbedded huge blocks, some of them angular, but most of them rounded and waterworn, which contain almost all the fossils that have been procured from that interesting locality. At Silewada, towards their lower part, there occur considerable number of compressed stems of trees in situ, one of which, presenting its thin edge in the side of a quarry, may be traced for about 20 feet. A few inches further down we come to the largest of the iron bands, which consists of a conglomerate, about six inches thick, enclosing fragments of dicotyledonous wood converted into a kind of jet, and impregnated with iron. Ferruginous bands are common not only at Silewada, but also at Bábulkedá and Tondákheiri. It is only, however, in the neighbourhood of Chanda that any one of them has been found to contain wood in silicified state.

B. Underlying the iron band we come to layers of much finer kind consisting of argillaceous sandstone, varying from white to yellow and

pink, and generally containing specks of mica. These strata, which are used for pavement and carved work, extend downwards for about 15 feet, when they gradually become coarser, until they are suitable for millstones. The entire depth of these layers, after their change from fine to coarse, has not been ascertained. Dispersed through them, as we saw was the case with the upper member, are occasional angular fragments, so that it is difficult to distinguish lithologically between the two, except that the inferior beds always contain loss exide of iron than the superior.

It is in the argillo-arenaceous strata that we have mot with nearly all the fossils which the sandstone of Silewádá, Bhokárá, Babulkhedá, Bharatwádá, Tondákheiri, Bázárgaum, Chorkheiri, and Chándá has yielded; and there is every reason to believe that the imbedded blocks of Kámpti also, which have furnished so many vegetable remains, were originally derived from them.

Chorkheiri and Chándá are the furthest limits north and south from which I have procured fossils of the inferior member of the sandstone; and the fact that the fossils are exactly the same, in addition to a resemblance in lithological characters, demonstrates that the strata are so also.

Between these two extreme points, however, under an outcrop of coarse sandstone of much the same character the generality of our upper beds, except that it is not coloured by iron or pervaded by iron beds, there are found at Mángali and its neighbourhood fossiliferous strata applied to the same architectural purposes our ordinary lower strata, though they differ from them in being of deep red colour, finer and more sectile, and with a larger admixture of clay and mica. As the Mángali red slaty sandstone contains scarcely any organic remains common to the inferior layers about Nágpur, it is not without hesitation that I include it under the present head, and arrange its fossils along with those of the more typical strata.

[Fossils of B.—For the same reasons as stated above, p. 268, in the case of the palæontology of the tertiary deposits, the numerous fossils of this division of the sandstone series are here merely mentioned in short, their detailed description being deferred until the publication of Part II. of this memoir.

These fine and coarse argillaceous sandstones, rich with plant remains, have afforded—

Labyrinthodont Reptile* (from Mángali).

The Brachyops laticens, Owen. See Quart. Journ. Geol. Soc. Lond., vol. x., p. 474; and xi., p. 73, pl. 2 [and this vol., p. 288.—H. J. C.].

Fishes; small jaws and ganoid scales.

Crustacoans; Estheria.

Plant romains.

Fruit and scods; numerous and undescribed.

Leaves; Conifer, Zamites, Poacites, and Forns (Pecopteris, Glossop-teris, Taniopteris, Cyclopteris, Sphenopteris).

Stoms; exogenous and ondogenous.

Acrogons; Aphyllum, Equiscites, Phyllotheca, Vertebraria.]

c. Between the sandstone quarries at Bhokárá and Korhádi granitic rocks have lifted to the surface, with a dip of 30° to SW., a series of red shaly bods; and between these and Bhokárá another species of green argillaceous strata, lying somewhat more horizontal. The relation of these two to the sandstone bods, from the absence of any good exposure, I have not been able to ascertain, but they would appear to underlie it. Besides the locality now named, these rocks are developed in the district north of Chándá, but they require to be distinguished from the green shale in the vicinity of the Mahádewas, which is associated with the bods of Indian coal, and rightly classed under the sub-division B. The red shale at Korhádi has yielded the following organic remains:—

Fossils of c.—A roptilian footmark of one-third of an inch long, and as much broad. Three or four specimens have been obtained, each exhibiting only one print; owing to the brittleness of the matrix, I am not sure that all the impressions are of the same kind.

On the same specimens that bear these footmarks are seen the tracks of wormlike animals. That the animals forming these tracks have been Annelids, resembling earthworms, will be evident to any one who considers the appearance of the furrows, the way in which the head has occasionally been pushed forward and then withdrawn, the tubular holes by which the ground has been pierced, and the intestine-shaped evacuations which have been left on the surface. Fossil worm-borings have been found in the green shale of Tadádi, NW. of Chanda, seventy miles S. of Nagpur.

The only vegetable organism which has been discovered in the shale is a sulcated plant, which most probably belongs to the genus l'hyllotheca; but, as a sufficient length of the stem has not been obtained to display the articulation, its precise character cannot be fixed.

n. Immediately below the red shale there are found beds of white marble at Korhádi, which have been greatly disturbed and delomitised

section obtained by Dr. Bell * we find sandstone, from 50 to 500; argillaceous limestone, 9 feet; and, after various unimportant argillaceous, bituminous, and calcareous strata, in all 4 feet; limestone 1 ft. 9 in.; laminated sandstone and shale, 8 feet; and argillaceous &c. strata as before, 11 feet 8 inches,—we come to limestone, 23 feet; then argillaceous and calcareous beds, 25 feet; red clay 27 feet; and limestone." Here it would appear that shale, sandstone, and limestone are interstratified.

Though there is no great development of carbonaceous beds in the district which is the more immediate subject of this paper, yet I should regard the communication as incomplete without some notice of the position of the Indian coal in reference to our saudstone strata. Bhuwán, in the north-west of our area, at the foot of the Mahádowa hills, furnishes us with a common term of comparison.

Thickness of the Strata.—A. The highest bods, as exposed in the quarries of Silewada and Bhokara, average about 25 foot of coarse sandtone, with iron bands, below which there are 15 foot of argillacoous sandstone, B, with an abundance of fossils, and an undetermined depth of coarse sandstone beneath. These constitute what Mr. Carter, in an able Summary of Indian Goology which I have just received, calls the "Panna" sandstone. From outcrops of this sub-division of the sandstone series in other localities near Nagpur, the whole thickness of the highest beds may be reckoned at about 200 or 300 feet. At Koth, as we have seem it ranges from 50 to 500 foot; at Mudaluity 120 foot; and at the Mahadewa hills, according to Mr. Sankey, 2,700 feet, which must be its greatest development. v. The depth of the shalos at Korhádi and Tadádi seems to be-green about 30 feet, red 50 feet. At Kolá, omitting interstratified argillaceous limestone and sandstone, all the argillaccous thin strata united amount to 29 feet, red clay 27; while at Newbold's section of Mudalaity, where the shalos, usually roddish, undorlie the limestone, they attain a thickness of 50 feet. p. The limestone which underlies the shale has been much disturbed by granite at Korhádi, so that we cannot fix its thickness procisely; but I should think it cannot be less than 100 feet—at Mudalaity it is 360 feet. Under this limestone, which is included in Mr. Carter's excellent paper along with shales and coal under the name of Kattra shales, there occurs, as Newbold has shown in Southern India, and Franklin in Bundelkhand, another series of sandstone rocks, for which Mr. Carter proposes the name of "Tará" sandstono; but as, most probably owing to tho

Bee also Quart. Journ. Geol. Soc, Lond., vol. x., p. 87-4, and note.

intrusion of the granite, this member of the formation does not occur in our neighbourhood, I have nothing to say regarding it.

Character of the Formation.—There can be little doubt that the upper strata are lacustrine. The occurrence in them of such an immense collection of terrestrial vegetation, intermingled with Poacites, taken in connection with the total absence of Fucoids and other marine plants, shows very plainly that they must have been deposited in fresh water. And, as no river could have covered the extent of surface which these bods occupy, we are bound to conclude that, like the tertiary rock previously described, they must have been formed in a lake, a conclusion which the discovery of Estheria (or Limnadia), with their two valves entire, and congregated together as they are found in their usual haunts, fully justifies. Again, the abundance of worm-tracks and borings in the rod shale of Korhádi, and the green shale of Tadádi, renders it more than probable that the strata at these localities constituted the margin of an ancient lake, and not of a sea or even of a river. Of the origin of the dolomitic beds it is impossible to give any certain account, owing to the transformation which they have undergone, though we may suppose they follow the analogy of the other members of the formation. The character of the upper strata at Elichpur, as would appear from the fossils discovered by Dr. Bradloy, is exactly the same as at Nägpur. Tho Lepidotus, which has been found at Kota, from its association with terrestrial vogetable remains, has been pronounced to have been probably an estuary or inshore fish; but, as the genus also occurs abundantly in the freshwater strata of the Woalden, it may be presumed that the strata at Kotá are not of a different origin from those in our neighbourhood. This supposition is rendered more likely by the fact that while no marine vegetation is said to have been detected there, a piece of the shale which Dr. Bell kindly sent me bears the impression of a bivalve exceedingly like - Cyrena or Cyclas. Dr. M'Clelland seems to suppose that the Bardwan coal-measures were deposited in a sea, for, in the last plate of his Survey already referred to, he has figured a fossil which he has called Fucoides venosus; but any person who compares the plant there represented with the Glossopteris figured in his Plate xv. under the name of G. reticulata will, I believe, agree with me in considering both plants generically, if not specifically, the tame. I infer, therefore, that there is no evidence whatever to prove that our sandstone, or the shale at Kotá, or the Bengal coal-measures, were deposited in the sea, but, on the contrary, every reason to believe that they were all formed in a large body of fresh water.

by the plutonic rocks above referred to.* Similar strata, but pink and blue, occur in the channel of the Pech at Gokala, a little above Parshiwani; and still higher up, at Nawagaum, it rises into a chain of eminences, which runs thence westward to Kumari. Following up the river still further, on its right bank we come to a patch of the same crystalline limestone at Dudhgaum, where it is in the vicinity of trap. To the east of this, at A'mbajiri, in Chanpur, it occurs again: but there, as in most of its other localities, the granito rises to the surface in the neighbourhood. Limestone is found also on the Lánji hills at Kunde and near Bhánpur, to the east of Hattá, but whether it is the limestone associated with sandstone, or just a calcareous phase of our freshwater tertiary formation, from not having visited the spot, I am unable to decide. It seems to be comparatively free from magnosia, in which it differs from the generality of the strata of which we are now treating. From the heat to which these have everywhere in our area been subjected in the process of dolomitisation, we need not expect to discover in thom any organic remains. Newbold thought that he had found in certain cherty veins of limestone near Karnúl myriads of spherical Foraminifora. We have also veins of chert in the Korhadi limestone which exhibit appearances that might be mistaken for the same objects, but they do not seem to be really organic. The minerals most abundant in the dolomite are tremolite and red and yellow stoatito, which last, when the surface of the rock is weathered, stands out in little prominences, as if it were a species of lichen.

The whole series of strata which we have designated by A. B, C, D, we conceive to be only sub-divisions of the same formation. They have been disturbed by the same granitic cruptions, and where fossiliferous bear a general resemblance to each other in their organic romains. But this mutual connection is more apparent when we compare the series within our area with strata beyond it. From Mr. Sankey we learn that the sandstone represented in the north-west corner of our map is succeeded, in a descending order, at Chotá Barkoie by bituminous shale with fossils and sandstone, and at Bhuwan, at the foot of the ascent to one of the Mahádewa or Pachmadi hills, by indurated green claystone and green shale, and bituminous shale with fossils. Again, below the sandstone in the south-east corner of the map, as we are

• 5g

This dolomite ought to be ranked with the metamorphic rock. The calcareous strata on the Lanji hills seem to be the only true representatives in our area of the argillaceous limestone of Southern India. In the Ragnur district, east of our area, argillaceous limestone abounds.—S. H.

informed by Dr. Bell, there occur argillaccous limestone, bituminents shale with fossils, and a few alternating layers of impure limestone and bituminous shale, until we come to a bed eight feet thick of laminated sandstone &c. Situated as our sandstone is between these two extrome points, and appearing to be a bond of connection between them, we might, à priori, expect that the intermediate beds would be of the same ago as those at the localities on either side; and this opinion is confirmed by the appearance of the sandstone near Nágpur, which shares, with the sandstones of the Mahadewa and Kota hills the distinguishing feature, first noticed in this neighbourhood, of being pervaded by ferruginous septa. These dark brown stripes, which in all their hardness protrude from the weathered surface of the enclosing rock. will be found, wherever they occur, a very good criterion of judging of the age of the sandstone. But besides identity in the arenaceous beds of our whole district, we can trace the same identity between the subjacent strata at Nagpur, Pachmadi, and in the Hyderabad country. The green shale at the Mahádewas and that at Tadádi are different.

At Kotá, according to a private letter with which I was favoured by (the late) Dr. Bell, red clay, of greater thickness than any stratum that was passed through, underlies the other shales which he has enumerated in his section, * and in localities further south Makcolmson states† that the shales on which the sandstone rests are blue, red, green, or pure white. The strata at Mundipár are metamorphic; and, as we are told by Newbold, t the sandstone of the Eastern Ghats frequently "passes into red and green argillaceous and siliceous slates and laminated marls." I think, then, that, though inferring the identity of Nagpur sandstone with that of Southern India, from the occurrence of diamends at Weiragad, Maleolmson's statement was wrong as to its grounds, yet it was perfectly correct as to its matter. The position of the shale in reference to the limestone seems to vary. At Korliadi it is the superior rock. Such also is its position at Bángnápilli, according to Malcolmson, § and generally according to Newbold. In a section, however, of the pass at Mudalaity, given by the latter writer, we have the following order: "compact light-coloured sandstone, 120 feet; limestone, 310 feet; shales, 50 feet; laminar and massive sandstone. Whereas by the

Quart. Journ. Geol. Soc., vol viii., p. 282.

[†] Trans. Gool. Soc., 2nd Sor, vol. v., p. 543 [and this vol., p. 7.—II. J. C.].

[#] Journ. As. Soc., vol. viii., p. 167.

Malcolmson, we swand, p. 541 [and this vol., p. 5.—II. F. C.].

Dr. M'Clelland's sentiments, which in 1816 were very decided as to the true Palæozoïc character of our Eastern coal,† seem to have remained the same at the period of his more recent publication on the subject. for we find him in his Survey, while admitting the Oölitic age of some bluish-white indurated clays at Dubrájpur, in the Rájmahál hills, nevertheless placing the shales, sandstones, and seams of coal of Bardwán, and of Mussinia and Kottikún, in the Rájmahal hills, as an intermediate formation, which he styles the "Coal-measure," between the Inferior Ocilite mentioned above and what he supposes to be the "Old Red Sandstone." After deducting specimens of Fucoides, which I cannot, with the aid of his figures, distinguish from those of Glossopteris, there are seven genera, to which he refers as "Indian coalmeasure fossils." Of these, four, viz., Sphwnophyllum, Poacites, Oulamites, and Pecopteris, he says are "common to the coal-measures of Europe." In the conclusion which would naturally be drawn from this statement I cannot concur; and hence it is necessary to review the grounds on which it is made. The three genera not mentioned are Zamites, Tanianteris, and Glossopleris. Of these the first two are held to be well night characteristic of the Jurassic period, while the remaining genus, though unknown in Europe, must, from the circumstances in which it is shown to occur, now be acknowledged to be equally a Mesozoic plant. And with regard to the four genera specified, I do not suppose that Dr. Roylo will assent to the identification of his Trizygia with Sphanophyllum, and, if any specimens of the genus Calamites had been preserved for description, have little doubt they would have proved to belong to our "nontuberculated class of opposito sulcated jointed stems," which abound in formations above the true coal-measures. The genera Poacites and Pecopteris I have found in our Jurassic strata, and a specimen of llio latter here is so like one figured by M'Clolland that it is difficult to resist the conviction that they do belong to the same species. If to the evidence now adduced there be added that afforded by the occurrence of the peculiar plants Vertebraria indica, Trizygia speciosa, &c. at Bardwan and Bhuwan, I think little probability will remain of the Bengal coalformation being Palæozoïc.

Dr. Hooker, in commenting on the opinion of Dr. M'Clelland, which he supposed to be in favour of the Oölitic age of the Bardwan coal-field,

t" There cannot, however, be a doubt as to its belonging to the true conflormation, from the nature of the coal itself, well as of the beds with which it is associated."—Secretary of the Calcutta Coal Committee on the coal of the Great Tenasserim River, in Committee's Report, p. 138. Calcutta, 1846.

at the commencement of his first volume, endeavours to prove that no inference can be deduced from the plants discovered in these strata. In his second volume, however, he puts forth an opinion of his own, which, though not formerly onunciated in regard to the Bardwan series of rocks, may be gathered from his remarks on the carbonaceous shales near Pankhawadi. On these shales there were "obscure impressions of Fern-leaves, of Trizygia and Vertebraria, both fossils characteristic of the Bardwan coal-field, but too imperfect to justify any conclusion as to the relation between these formations.* And then in a footnote it is added, "these traces of fossils" (including a fragment of bone, as well vegetables) "are not sufficient to identify the formation with that of the Siwalik hills of North-West India; but its contents, together with its strike, dip, and position relatively to the mountains, and its mineralogical character, incline me to suppose it may be similar." It may appear presumptuous in me to impugn the view of one who, from personal no loss than hereditary claims, is entitled to the utmost respect on the subject of vegetable remains. I feel, however, that the learned author has been led away by his distrust of the ovidence afforded by fragments of plants to rely on the more uncertain indication of mere lithological phenomena. Do strike, dip, &c. furnish us with such strong testimony on the question of age that for their sake the Pankhawádi shales are to be denied a place with the Bardwan beds which have Forns, Trizygia, and Vertebraria, and to be ranked with the Siwálik rocks, which, I bolievo, have none of the three? Or, if the carbonageous strata at both places are allowed to be contemporaneous, are both to be classed as Miocone or Pliocene whon the Bhuwan shales, which like them exhibit "impressions of Forn-leaves, of Trizygia and Vertebraria," ropresent sandstones whose numerous fossils, not to mention those of Bardwan itself, are decidedly not more recent than Jurassic?

It only remains to add that the age of the dolomitised limestone cannot be expected to be determined by the evidence of fossils; but main other localities it is not unfrequently found to alternate with the shale c, it may be set down as nearly coeval with it;—thus making the whole series of rocks from a to a to correspond with the lower members of the great Jurassic formation,—reaching perhaps from about the position of the Scarborough strata downwards into the Lias.

VIII. Plutonic and Metamorphic Rocks.—At the end of a paper which has already extended to such a length it would be unbecoming to say

^{*} Himalayan Journals, vol. ii., p. 403.

Age of these Strata.—The coarse iron-banded sandstone above, and the more fissile strata lying conformably below, which are undoubtedly of one and the same era, require first to be considered.* For the sake of clearness, however, I shall refer to the latter member alone, as it has afforded most of the fossils, and furnishes the best data for comparison with the rocks of other localities. Some of the seed-vessels which it has yielded bear no very distant resemblance to those of the Stonesfield slate; Asterophyllites (?) lateralis, to use the provisional name proposed by Bunbury; and the forms of Pecopteris show its near connection with the carbonaceous shales and sandstones of Scarborough; Phyllotheca, Glossopteris, and the narrow fronds of Oyclopteris, if M'Coy's figure † be truly of that genus, mark out the relation to the coal-beds of Now South Wales, while Tæniopteris magnifolia, and sulcated stems in all respects corresponding with Phyllotheca, testify to the agreement with the Virginian carboniferous strata. These coincidences, some of which, as in the so-called Asterophyllites (?) and Tæniopteris magnifolia, seem to amount even to specific identity, along with the remarkable relations which the distant localities exhibit among themselves, form a network of proof, which, in my opinion, binds down all the various series of rocks to about the same epoch,—an epoch which the known position of the Stonesfield and Scarborough strata shows to be Lower Oölitic.

Whether the Mángali sandstone is to be rockoned contemporaneous with these; whether the two different kinds of strata thoro-the coarso thick-bedded upper and the fine fissile lower—are to be reckened the equivalents of our A and B, is a question which observation in the field, and a comparison of the respective fessils, do not enable me to answer. The massive sandstone at Mángali, as has been said, is dostitute of iron bands, and the inferior argillo-arenaceous strata are much redder than ours; and especially the organisms of the lower strata at the two places are very dissimilar. Here they are all vegetable, while there they are almost exclusively animal. Only one of the fossil plants at Mangali appears to us to bear resemblance to anything found in this vicinity. At the same time; if any inference is to be derived from the succession of the rocks there, it is in favour of the idea that they are the counterparts of our A and B. And that they cannot in age be far removed from them is proved by a comparison, not of the Mángali fossils with others in this territory, but of both these with those across the Atlantic. Our

Professor Oldham states that there is considerable inconformability between these in Katiák.—S. H.

[†] Ann. Mag. Nat. Hist., vol. xx., pl. ix., fig. 3.

investigations in the resemblances of the sandstone fessils show that the Nágpur fossiliferous strata are connected with the Richmond carboniferous formation by Teniopteris magnifolia, while the Mángali fossiliforous strata are still more closely linked to it by the discovery of what appear to be Aspidiaria, Knorria, and the interesting groups of large and small Limnadiada. Here, then, we perceive that the lower beds at both of these Indian localities bear a relation to the Virginian coal measures, characterised by an apparent specific identity of fessils; and though the genera of which the species seem to be identical are not the same in both cases, yet it is obvious, from the sort of ex æquali argument which we may be permitted to use, that these lower beds must stand pretty closely connected with each other. But I do not wish to push to an extreme reasoning on a point which the progress of investigation here may soon elucidate by finding the strata under consideration in juxtaposition. Meanwhile I consider myself waranted in asserting that our Mangali rocks cannot at all events be older than the Jurassic, if under that term the Lias is also included. Indeed the head of the Labyrinthodont tends to communicate to them a Triassic aspect; but if the Jurassic character of thou abundant flora be taken as the real indication of the age of these rocks, we arrive at a conclusion which brings out the interesting fact that the family of Labyrinthedonts, instead of being confined to the Coal and Trias, survived (in the East) until the period of the Lower Oblite.

Regarding the age of our shale c, which there is every reason to believe underlies the coarse and fine sandstones A and B, I have little to say more than that it cannot be much older than these. The occurrence of worm-tracks, well as of faint traces of Phyllotheca, will not allow me to consider it anything but part of the same Jurassic formation.

But, as I have endeavoured to show that the coal-measures of Bard-wan are equivalents of our plant-bearing beds, and therefore belong to the Lower Oolitic group, it will be necessary to make a few remarks to establish the correctness of this view. On the age of the coal measures of Bongal two opinions have been submitted to the public within the last four years—one in 1850 by Dr. M'Chelland in his Geological Survey, and the other in the course of the present year by Dr. J. Hooker in his interesting Himalayan Journals.*

^{[*} This portion of the paragraph on the "Age of the Sandstone" has been remodelled since the reading of the paper, so as to introduce the necessary references to the opinions published by Dr. J. D. Hooker in his most interesting work on the Himalayas.—June 14 and September 6, 1854.]

much on this part of our subject. We have in the city of Nagpur, and many localities to the east of it, the usual combination of gnoiss and quartz rock, mica and hornblende schist, with massive granite. The peculiarity of the lastmentioned rock in the streets of the capital is that it is generally a pegmatite, consisting of flesh-coloured crystals of felspar with quartz, disposed so - often to take the appearance of graphic granite. But very frequently it occurs with the felspar compact in large white masses, which then have much the appearance of a pure dull porcelain. In Nagpur the most common rock is gneiss, passing into mica schists. The former rock when fresh is quarried, though not extensively, for building, and when disintegrated for the repairing of the roads. But for both of these purposes respectively trap, in the two conditions mentioned, is preferred. Masses of white quartz appear here and there in the city, some with crystals of black schorl, and others with scales of gold-coloured mica. The range of plutonic hills on the west of Kampti, which is indeed only a narrow prolongation of the great grantic district in the Wein Gangá basin to the cast, has been thrown up by an eruption of granite corresponding nearly with the course of the Kolar. The massive rock which lies in the channel of the river, mulike that of Nagpur, is generally groy and very micaceous. Above it, forming the N. base of the range, lies mica schist, passing into granular schistose quartz, which is overlaid by a stratum of dark-groy, glistening, resinous quartz, and then by a considerable thickness of white quartz with scales of mica. This constitutes the ridge of the range for about its entire length from Waregaum to Gumtara, and with its snowy whiteness attracts attention from a great distance. At the northorn base of the range, between the quartz and the delomite of Kerhadi, there are interposed some beds of granular quartzose rock which has very much the appearance of being an altered sandstone, in which case it might be the representative in this part of the country of the "Tará sandstone." But throughout the field of crystalline limestone at Korhádi there are quany oruptions of granite, which just rise to the surface, without any intermediate metamorphic rocks at all. In some of those instances the granite is garnetiforous, and at its junction with the dolomite the latter, besides its usual ingredients of steatite and tremglite, is intorningled with mica. At Hályádoho, NE. of Umred, mica schist with garnets is quarmed for pavements; it abounds along the course of the A'mb river. At Segaum various plutonic rocks rise from under the sandstone, and extend northwards to Karsingi. The first, which appears in the north street of Segaum, is syenite, in which the felspar and hornblende greatly

preponderate over the quartz. About 300 yards to the north this is succeeded by another kind of syenite, in which red felspar is combined with a small proportion of quartz, a large quantity of a green mineral (epidote or diallage?). This rock (emphotide?) sooms to be massive, and, if we may judge from the fragments of it lying on the surface, is the prevailing rock for some miles. In an adjoining plutonic area a little to the north there is an extensive development of potstone at Jámbul Ghát. The rich dark kind that possesses a dull metallic lustre has hitherto been reserved by Maráthá authority for the manufacture of idols; but the lighter-coloured varieties, which are more common, occurring also at Dini, near Rámpaili, and at Biroli, on the Wein Ganga, near Tharorá, have been long used for fashioning into vessels. Steatitic schists of a pure white tint, with a few imbedded garnet crystals, occur at Kaneri, on the Chulband river, and at various other localities east of the Wein Gangá. In many parts of this rivor's course, and in the Lanji hills, hornblende rocks, both schistoso and massivo, abound. A coarse kind of corundum occurs at Pohorá, in the parganná of Sáhangadi, on the south of the road from Nagpur to Rayopur.

/ Metals.—Small quantities of gold are found near Lánji in the sands of the Sonriver, a tributary of the Wein Ganga. In some fragments of quartz rock on Nimá Hill, west of the Pech rivor, Colonel Jenkins found galena. Where this rock is associated with dolomite, as at Kumári, it contains manganese. But the principal ore which it yields is iron; this may be obtained in immense quantities in the province of Chanda, both on the east and west of the Wein Ganga. Near Dowalgaum, only three miles from the east bank of this navigable stream, which communicates by the Godávari with the Bay of Bengal, in the midst of a level country covered with jungle, there is a hill named Khandeshwar, consisting of strata tilted up at an angle of 60° or 70°, the dip being to the north. The summit of the hill is about 250 feet above the level of the plain, 100 feet being gradual ascent through jungle, and the remainder an abrupt wall of naked rock. The iron ore is for the most part specular, though many specimens possess polarity, and seem to be magnetic. It is on the surface of the slope that it is most valuable; but the whole mass, from an unknown depth under ground to the highest poak above it, is richly laden with metal. This single hill might furnish iron for the construction of all the railroads that shall ever be made in India, and with its abundance of fuel and choapness of labour, and convenience of situation, it is admirably adapted for an export trade to every part of the country. But bosides this locality, there are

others in the neighbourhood which could each contribute an unlimited supply of the same indispensable metal. Among these may be mentioned Lohárá, Ogalpet, and Metápár, Bhánápur, Menda, and Gunjáwahi, which are all on the W. of the Wein Gangá; and at all of which places the ore seems to occur in quartz, and is sometimes granular, but for the most part compact. Unimportant crystals of it are scattered through the pegmatite of the capital. Notwithstanding that the specular ore is so abundant, there are many districts on the north of those already named where the hydrous exide, in the shape of the heavier lumps of laterite, are selected for smelting by the poor natives, whose tools are anything but adapted for contending with the hard masses of the metamorphic matrix or gangue.

Age of the Plutonic and Metamorphic Rocks.—Thoso evidently do not all belong to one and the same epoch. Colonel Jenkins observes that at Nayakund, on the Pech, to the north of Nagpur, he met with "a grey granite, composed chiefly of whitish felspar in very large crystals," a mass of which "was distinctly traversed three or four times by granite veins, accompanied by as many heaves." The granite of the veins was smaller-grained and redder the more recent it was, and, to the best of that officer's recollection, was destitute of mica. Without, however, more extensive artificial sections of the rocks in this noighbourhood than have ever been executed, I fear it will be difficult to fix the respective ages of the different eruptions. A cursory view of the question would lead to the supposition that the micaccous granite is more ancient than the pegmatite; but, in areas where both are presented in the vicinity of each other, the soundness of this view may be questioned, or at all events it appears to be impossible, in the present state of the country, to have it confirmed. The pegmatito of Nagpur city, which wo have said is associated with gneiss, mica schist, and quartz with mica and with schorl, is evidently a very recent oruption, for it has not only converted much of the very highest member of the Jurassic sandstone into gneiss, but it has completely upheaved it. That the oruption, therefore, was posterior to that formation, there cannot be the slightest doubt. But it has sometimes occurred to me, though the observations of the most eminent Indian geologists are opposed to the thought, that this pegmatitic outburst may be subsequent even to our trap.

The section (Pl. VI., fig. 2) may throw some light on this doubtful point. In this section we have the everlying trap (a) occupying the two summits of Sitabaldi Hill, under it the tertiary freshwater formation (b) and the intraded amygdaloidal trap (c) which has encreached on it.

At the foot of the hill is the upper sandstone (d), which has been metamorphosed to a great extent by the gnoiss (e), or rather by the pogmatite (f) beneath. On the north part of the hill the gneiss comes to the surface; but a little further north it is, together with the sandstone, overlaid by trap. This trap, which agrees with that overlying the tertiary beds in being nodular and poor in minerals, resembles in the very same respects the amygdaloid where it constitutes the superficial rock on the ascent. Proceeding in the same line, we find the trap cease and the sandstone upheaved. After this interruption the trap is again seen to be on the surface. Now the question arises: what is the reason that the trap is not found where the granite has thrown up the sandstone? The most obvious roply is that once it was there, as it is seen on either side, but that by this oruption it was removed; in which case the plutonic rock would be of more recent origin than the volcanic. But, as there is the alternative of the latter never having been spread over the position of the former, and as this alternative is favoured by the examination of other localities, I content mysolf with morely submitting the case for determination, and stating that my latest observations lead me to believe that the trap is of later ago than the granite. At all events the section undoubtedly shows that the pegmatite and some of its accompanying gnoiss are of an age subsequent to the upper sandstone. And yet in a layer of conglemerate contained in the red shale of Korhádi we meet with pebblos of undulated mica schist very like that which occurs in the present day between Suradi and Kerhudi. Rocks of this character, then, whether we are right or wrong in suggesting their connection with any still existing, did exist before the deposition of the red shales.

Conclusion.—In tracing the geological history of this district from the facts that have been brought forward, we are made to feel that the early epochs are involved in the utmost obscurity. While in many other countries the records of what took place in Palæozoïc times have been preserved in successive strata of the earth's crust, in the Dakhan they have been wholly obliterated. It is not until we come down to the Jurassic era that we meet with archives whose characters can be read. Then we find that Central India was covered by a large body of fresh water, which stretched southward into the Peninsula, and eastward into Bengal, while on the north and west it communicated by some narrow channel with the sea. On the shore of this lake earthworms crawled, and small reptiles (frogs) crept over the soft mud. In its pools sported flocks of little Entomostracans resembling the modern

Estheria, mingled with which were Ganoid fishes and Labyrinthodonts. The streams which fed it brought down into its bed the débris of the plutonic and metamorphic rocks which then constituted the greater part of the dry land, and which were covered with an abundant vegetation of Ferns, most of them distinguished by the entireness of their frends. Low-growing plants with grooved and jointed stems inhabited the marshes; and Conifers and other Dicotylodonous trees, with Palms, raised their heads aloft. Meanwhile plutonic action was going on, and strata, as they were formed, were shattered and reconstructed into breecia; and finally an extensive outburst of granite elevated the bed of the lake and left it dry land. The sea now flowed at Pondicherry and Trichinopoly, depositing the cretaceous strata which are found there.

At the end of this epoch Contral India suffered a depression, and was again covered by a vast lake, communicating with the sea, not towards Cutch as before, but in the neighbourhood of Rajamandri, to which the salt water had now advanced. When the lake had, during its appointed time, furnished an abode to its peculiar living creatures and plants, it was invaded by an immense outpouring of trap, which filled up its bod, and left Western and a great part of Central India a droary wasto of lava. But these basaltic steppes were ere long broken up. A second cruption of trap, not now coming to the surface, but forcing a passage for itself under the newer lacustrine strata, lifted up the superincumbent mass in ranges of flat-toppod hills. Since thon, to the east, water has wept over the plutonic and sandstone rocks, and laid down quantities of transported materials impregnated with iron, and some time after there was deposited in the west a conglomorate, imbedding bones of lago mammals, and above it a stratum of brown clay, which immediately preceded the superficial deposits of the black and red soils.

P.S.—I have to acknowledge my great obligations to Lioutenant Colonel Alcock, of the Madras Artillery, and Dr. Leith and Mr. Cartor, of Bombay, for assisting me in obtaining access to books (or extracts from them), of which I should otherwise have been deprived.

The map of the district described is coloured geologically from an excellent political map given in Rushton's Bengal and Agra Gazetteer for 1842. The formations between Chindwada and the Mahadewa Hills are laid down from a sketch obligingly furnished to me by Mr. Sankoy.

Description of the Cranium of a Labyrinthodont Reptile, Bruchyops Laticeps, from Mangali, Central India. By Professor Owen, F.R.S. F.G.S. [With a Plate.]*

[Read June 21, 1854]

Tur fossil obtained by the Rev. Messrs. Hislop and Hunter from the sandstone series of Mángali, about sixty miles to the south of Nágpur, and transmitted for my examination, is a considerable portion of a skull, wanting chiefly the tympanic pedicles and the lower jaw; it is imbedded in a block of bright brick-red compact stone, with its upper surface exposed. The skull (Pl. XII.) is broad, depressed, of an almost equilateral triangular form; the occipital border or plain rather exceeding in extent each lateral border, which borders converge with a slight convex curve to the rounded obtuse muzzle. The breadth of the occiput is 4 inches 9 lines, and the extent of each lateral border of the skull in a right line is 4 inches 6 lines. Most of the cranial bones are impressed by rather coarse grooves, radiating in each from a prominence which indicates the primitive centre of ossification, the intervening ridges being in some parts broken up by communicating grooves into tubercles. The orbits (o, o) are entire, of a moderate size, of a full oval form, and situated in the anterior half of the skull. The middle line of the upper surface of the skull is slightly depressed; at the upper and fore part of the skull on each side there is a smooth continuous groove of a sigmoid form, with a strong curve convex outwards anterior to the orbit, and with a less strong curve convex inwards on the inner side of the orbit: between the orbit and the occiput there is on each side a shorter groove, extending from the exoccipital forwards and little outwards to the postfrontal, where it bends more directly outward and downwards behind the orbits: these grooves probably lodged large mucous canals. Portions of small, conical, pointed, subequal teeth extend in single series along the alveolar border of the uppor jaw (fig. 2, 21), from the muzzle along the lateral borders of the fossil, to two-thirds of an inch behind the orbits. At the bases of some of these teeth may be discorned indentations converging from the periphery towards the centre of the dentine.

The entire orbits, closed below by a backward extension of the superior maxillary 21, and the connection of this bone by a malar 26 and squamosal 27 with the mastoid 8 and tympanic 28, forming a complete zygoma, prove that the fossil did not belong to the class of fishes;

Repunted from the Quarterly Journal of the Geological Society of Loudon, vol, xi., part i, p 87.—February 1855.—II J C.

whilst the strong points of resomblance which the skull presented to the Labyrinthodonts—in its broad and very depressed figure (especially the great breadth of the occiput), in its external sculpturing (specially the number and position of the mucous grooves), in the form and position of the orbits, and in the characters of the teeth—led me to investigate the structure of the deeper part of the occiput, which was concealed in the matrix, for the more decisive character which that part of the cranium affords of the batrachian affinities of the singular reptiles to which the Mangali skull seemed, by its more obvious characters, to be most closely allied.

I was gratified by finding that the occipital bone (which, like the rost of the skull, was distinguished from the rod matrix by its yellow colour) terminated posteriorly in two well-defined subdepressed convex condyles not so close together as in the great Labyrinthodon salamandroides (Mastodonsaurus of Jaeger), but separated as in the Trematosaurus of Burmeister.* A part of the broad atlas (a) was found in connection with these condyles.

The superoccipital region is formed by a pair of bones, 3,3, each with a slightly prominent centre at the angle between the horizontal and backwardly-sloping part of the occiput: they may represent a divided superoccipital bone, but I cannot trace a suture separating them from the exoccipitals supporting the condyles, where it is represented by Burmeister in the *Trematosaurus*.

External to these is a large bone with well-marked prominent centre, from which the grooves of the outer surface radiate: on the left side a part of the tympanic remains in connection with this bone, which I regard as the mastoid 8, which bone occupies a similar position in the Labyrinthodonts. The parietal bones 7,7 continue the cranial walls in advance of the superoccipitals, and show small oval vacuity in their median suture—the "foramon pariotale," as in the Trematosaurus; the foramon is situated near the hinder part of the suturo; an accessory parietal" extends outwards from the hinder part of the main body of the bone on each side, to the angle between the superoccipital and mastoid. Traces of a suture seem to show this to be a dismemberment of the parietal: it occupies the place of the bone mark. ed n, and called "os temporale squamosum," in the abovecited figure of the Trematosaurus; but the true squamosal is always anterior and external to the mastoid in the reptiles in which it is unequivocally present; and it is restricted to its zygomatic place and functions, not

Die Labyrinthodonten, 4to, 1840, part i. pl. 1.

becoming a proper cranial bone until the mammalian type is reached. The precise boundaries of the frontal and the sutures dividing it from the nasals and prefrontals cannot be traced, the skull being abraded at this part. The postfrontals 12 have their contre as well marked and prominent as in the mastoids, and extend to those bones from the outer and back parts of the orbits. Traces of the malar and true squamosal 27 may be discerned on the left side, extending from the slender maxillary boneath the "postfrontal" to the tympanic 28, beneath the mastoid 8. The bone here called "postfrontal" is the "os orbitale posterius" (i) of Burmeister, and the name "os frontale posterius" is restricted in the abovecited figure of the Trematasaurus to a supplementary bone which is interposed in that Labyrinthodont, as in the present, between the bone marked 12, the parietal, and frontal where it forms the inner half of the back part of the orbit. This bone appears to me to be a dismomberment of an unusually developed postfrontal, and both it and the supernumerary bone " are remarkable departures from the normal cranial structure, characteristic of somo, if not of all, of the Labyrinthodont batrachians. The marked departure in the form and proportions of the present cranium from those of the equally well-preserved specimens of European Labyrinthedonts leads me to the conclusion that the Mangali species indicates a distinct subgenus in that group of reptiles, and I propose to designate the species so represented by the term 'Brachyops* laticeps,' indicative of its peculiar proportions.

Although the abraded and otherwise mutilated state of the skull of the Brachyops is such as to prevent my giving a more extended anatomical description of it, and determining more precisely and satisfactorily the boundaries and homologies of the constituent bones, it nevertheless permits so many characters of the skull of the Labyrinthodont Batrachia to be determined as can leave no reasonable doubt of its true nature and affinities; and thus the results chiefly required by the 'geologist, in reference to the probable age of the stratum in which this fossil is imbedded, may have been attained.

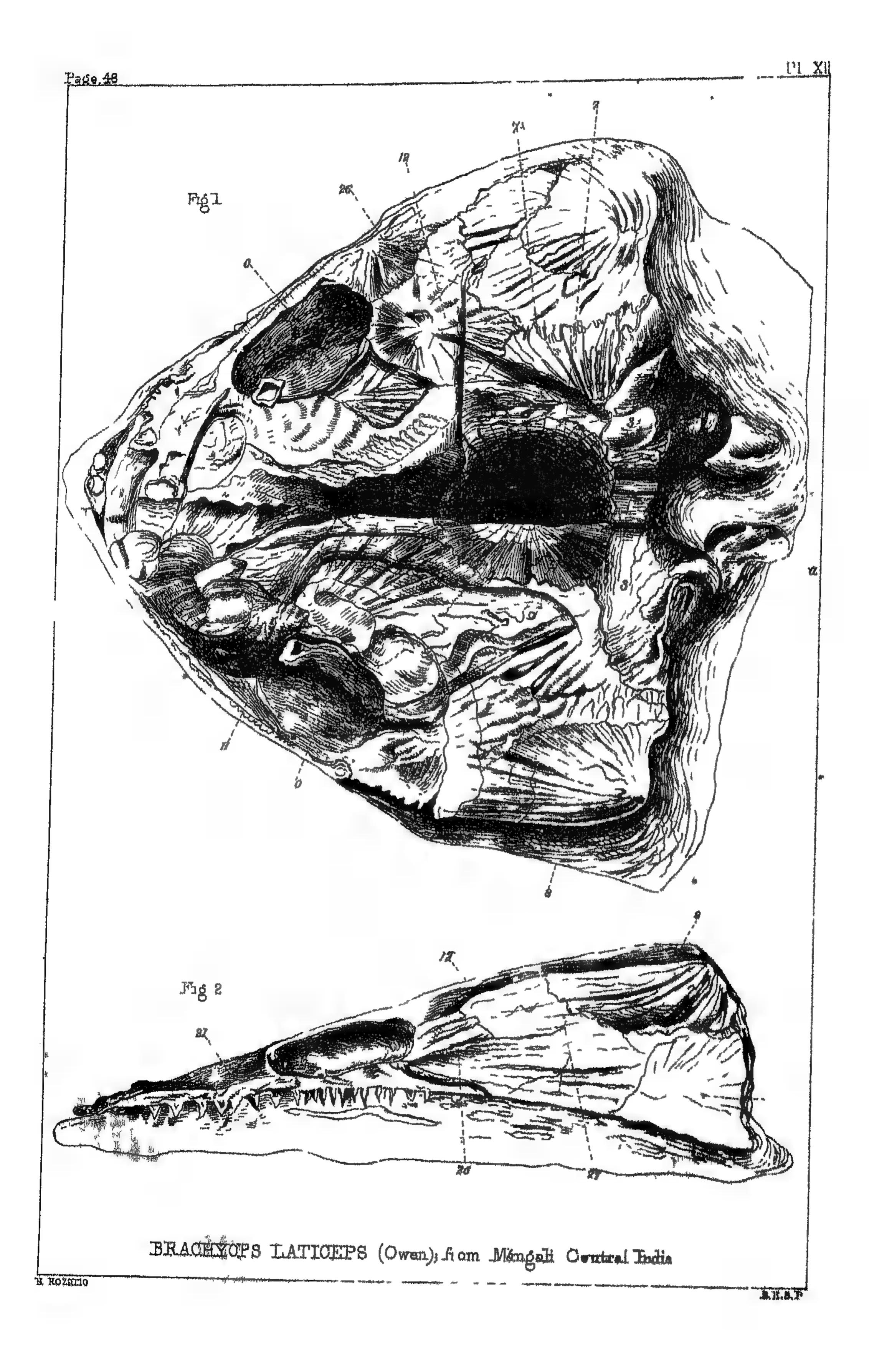
DESCRIPTION OF PLATE XII.

Fig. 1. Upper view of the skull of the Brachyops, nat. size.

2. Side view of the same, nat. size.

^{*} From $\beta \rho a \chi ds$, short; $\delta \psi$, face; in reference to the shortness of the facial part of the skull anterior to the orbit.

[†] Whon samily of animals is of considerable extent, it becomes necessary to indicate to what division of it sparticular genus belongs. This is doubly requisite if a question of geological age depends the determination of the point. Such happens to be the case in regard to the Brackyops described above by our great comparative anatomist. It is well





On the Connection of the Umret Coal-beds with the Plant-beds of Nágpur, and of both with those of Burdwan. By the Rev. S. Hislop.*

[Read June 13, 1855.]

In the observations on the Jurassic formation of the Nagpur territory, which I had the honour to submit to your Society, I showed that it consisted of four members in the following descending order: A, thick-bedded coarse forruginous sandstone, with a few stems of trees; B, laminated sandstone, exceedingly rich in vegetable remains: C, clay-shales, of various colours, in which are found the traces of reptiles and worms; and D, limestone, which within our area is generally crystal-lised from its contact with plutonic rocks. At the time of penning these remarks, not having had an opportunity of inspecting any of our Indian coal-measures, I was inclined to regard them as the equivalents of our argillaceous strata marked c; but having recently enjoyed this privilege, while out on a Mission tour with my friend the Rev. R. Hunter, I propose to communicate the medifications which have in consequence been wrought on previously-formed views.

Our tour extended about 120 miles NNW. of the city of Nagpur,—a distance which carried us past the carbonaceous strata near Unret, as far as the bituminous shales at the south base of the Pachmadi or Mahádewa Hills. These localities had both been visited by Dr. Jordon and Lieutenant Sankey in 1852, and the results of their investigations have been laid before your Society.‡

known that Labyrinthodontidæ have been found in more than one formation. The British remains of this family, which were formerly supposed to be Triassic and therefore Mesozoic, are now, in consequence of more accurate observation of the strate, assigned to the Permian formation or Palaeozoic epoch. But there are still, in the Keuper of Germany, genera whose claim to be regarded as Mesozoic has not yet been disputed. Among these there is one, named by Von Meyer Metopies, which he includes in his sub-family of Prosthephthalmi, from its having the orbit of the eye situated nearer the muzzle than the nock. Now the Brachyops is remarkable for this peculiarity, and therefore ought to be classed under the Prosthephthalmi of the Keuper, and not with the Permian Labyriniko dents, whose eyes are placed either in the middle of the semicranium or behind it. These observations, which in substance I communicated to the London Geological Society, along with the specimen which suggested them, have not been referred to by Professor Owen, but I call attention to them here, as I shall have occasion to make use of them in a subsequent note, when I come to sum up the arguments which in my opinion tend to prove the Jurassic ago of the Mangali and associated rocks.—Note by the Rev. S. Histop, August 1856.

^{*} Reprinted from the Quarterly Journal of the Goological Society of London, vol. xi., part i, p. 555, November 1855.—II. J. C. † Vide this vol., p. 273.— II. J. C.

[#] Quart. Journ. Gool. Soc., vol. x., p 55

The coal-field of Umret is about five miles north of the village, near a small hamlet dignified with the name of Bari, or Great, Barkoi, to distinguish it from Chhoti, or Little, Barkoi, which lies three-quarters of a mile to the south. Leaving Umret the traveller passes over granite for about mile, when he begins to ascend trap-hills, which continue, with only a slight reappearance of plutonic rock in the low ground near Tawari, until within three-quarters of mile of Chhoti Barkoi, where they end in an abrupt descent, at the foot of which there emerge beds of sandstono, that constitute the surface rock to the rivulet at Bari Barkoi. This stream has cut a passage through the sandstone, and laid bare the dark-coloured strata underneath, which are seen to dip at an angle of 5° to the WSW., the direction in which the water flows. The exposure displays the following succession: overlying sandstone, about 50 feet thick; coal, 11 or 2 feet; argillaceous shale, 3 feet; bituminous shale, I foot; arenaccous and micaccous shale, 3 feet; and white sandstone, depth unknown.

On observing the strata and the order in which they occurred, I remarked to Mr. Hunter that the shale would probably turn out to be the representative of the fissile sandstone, abounding in fossils, that is so well developed at Kámpti, Silewádá, Bhokárá, Bharatwádá, &c. In hazarding this conjecture I took it for granted that the overlying rock was the common sandstone of this country, which is for the most part traversed by iron bands. Search having been made, the iron bands though not of the typical character, were discovered. So far the hypothesis was confirmed.

Additional light was thrown on it by examining the circumstances under which the argillaceous and bituminous shales are met with at the Mahádewas. The sandstone forming the mass of that mountain range must be about 2,000 feet thick, and presents a line of bold mural crags extending E. and W. for upwards of twenty-five miles. The front of the precipice is towards the south, while the strata dip at an angle of 5° to the north, or, more correctly, NNE. However much the thickness of those arenaceous bods exceeds that of the forruginous sandstone in the immediate neighbourhood of Nágpur, there can be no doubt that both rocks are the same, as both possess the same iron bands, which I consider positive evidence of identity, when they do occur, though their absence may not be conclusive as to dissimilarity. Under the sandstone there are about eight feet of green shales, becoming more micaccous and laminated below, and succeeded for about three feet by bituminous shale, which disappears under the surface of the ground. Unlike

Barkoi, there is no seam of coal to be seen, but the tendency to it in the bituminous shale is manifest enough; and, indeed, this latter bod, as I shall endeavour to show when I come to speak of the organic remains, is palæentelogically a part of our Indian carboniferous strata.

Here, then, at Barkoi and the Mahádewas, as well as near Nágpur, we have the same thick-bedded iron-banded sandstone overlying in the last-mentioned locality more fissile strata of a somewhat similar material, but at the former two places superposed on argillaceous and carbenaceous or bituminous shales. Are then the lower beds also of the same age in all three localities? Of the contemporancity of the inferior strata at Barkoi and the Mahádewas there cannot be two opinions; but at those in our immediate neighbourhood differ in colour, and to a considerable extent in composition, some hesitation may be felt in including them in the identification. It may be supposed that there is a deficiency in the one district which is supplied in the other.

Now it may help to remove doubt to mention that even in this vicinity (Nágpur), where the lower strata are generally of a whitish hue, they present in their higher portion a certain quantity of clay, which becomes less and less as we descend, until at last, as in the underlying beds at Barkei, we arrive at pure sand. And, to complete the analogy in regard to composition, it may be added that in a particular spot at Bhokárá, six miles N. of Nágpur, the higher lamine new referred to exhibit not only the argillaceous mixture, but an approximation to the carbonaceous colour, being quite brown through the amount of comminuted vegetable matter which they centain.

But for direct proof of identity in age an appeal must be made to the fossil contents of the strata under comparison. At Barkoi we found the following genera: Glossopteris and Oyclopteris with Phytlotheca, Vertebraria, and other stems, and a variety of fruits or seeds. At the Mahádowas, during the very hurried visit which we made to that locality, we discovered Glossopteris, Phytlotheca, Vertebraria, and fruits or seeds; besides which, I believe, our friend Mr. Sankoy had previously brought to light specimens of Pecopteris, Sphenopteris, and Trisygia.

In regard to the Barkoi plants, I think there is scarcely one that cannot be specifically matched with some one from the laminated argillaceous sandstone in the vicinity of Nágpur. Of the genus (lossopteris the bituminous shale furnished several species; but among them there is not one that strikes me as not having been observed before in our arenaceous strata. The Cyclopteris of Barkoi exactly agrees with that

of Bharatwada, both being oblong-cuneate, and characterised by the same venation. The most abundant Phyllotheca at Barkoi is one with ten sulci, which is also the one most frequently discovered near Nagpur. Of Vertebraria there does not appear to be more than a single species, though Royle* has found a V. radiata from a transverse section of the stem of his V. Indica, and M'Coy† has added another species, V. Australis, from New South Wales, because there is a slight difference in the radiations of his transverse section from those of Royle's.

Taking the Vertebraria found at Barkoi as belonging to the only species hitherto discovered either in India or Australia, it is satisfactory to ascertain that it is just as abundant in all the localities of our sandstone as in the coal-formation of Barkoi. Besides the Vertebraria there is another stem common at Barkoi which has its exact counterpart nearer Nágpur. It is undescribed, but may be distinguished by its nearly opposite leaf-scars, and occurs plentifully in the laminated sandstone of Silowádá. The fruits or seeds from Barkoi I have not at present the means of comparing with those of Kámpti. One of them, however, may be easily recognised as identical with a fruit or seed lately met with at Bharatwádá.

Between the vegetable remains of the Mahadewas and those of our laminated sandstone a like comparison might be instituted. If, for example, Mr. Sankey's *Pecopteris* from that locality agreed, as my memory suggests, with one figured by M'Clelland, then it must have corresponded with one that occurs at Kampti. The *Vertebraria*, both

^{*} Illustrations of the Botany &c. of the Himalayan Mountains. Whon I formerly referred (Journ. No. 43, p. 871, &c, and MS. account of the fessil plants) to this remarkable genus of plants, I had not in my possession a specimen from the Indian coal-shales. The recent examination of many such has served to morease in my mind the conviction that its character has been misunderstood. Its smaller branches are somewhat slender and apparently winged. Sometimes they are found lying along the plane of the lamine,—at other times running across it. When a branch is discovered in the former situation, it is found to be split in two halves, with the wings that he in conformity with the lamination stretched at their full broadth, while those that lie at an angle with it are, as it wore, fore-shortened. In this case there is no trace of radiation. But when a branch is found running across the lamine. often happens, all the wings have equal room to retain their form, and hence the radiated appearance. The number of the radii or wings differs in specimens which I have examined from the same locality, and, as I believe, in portions of the same plant. A similar want of uniformity in this respect is perceptible in the specimens figured by Royle. That there is any such thing un dichotomous-veined foliage between the radii does not appear from the shale specimens that have fallen under my notice. On the contrary, they seem to be wholly destitute of leaves. But there is every reason to think that our sandstone specimens possess these appendages, and that they are of a narrow linear shape, like those of the Phyllotheca.

[†] Ann. and Mag. Nat. Hist, vol. xx., p. 147.

¹ Report of Geological Survey for 1848-49.

at the Máhadowas and noar Nágpur, might be proved to be identical, and a general resemblance pointed out in regard to (llossophris, Phylototheca, and the fruits or seeds. But after the statements of the provious paragraph it is scarcely necessary to enlarge.

From the above numerous coincidences it may be inferred that our laminated sandstone is the equivalent of the carbonaceous and bituminous shales in the north of this territory. It follows, as a matter of course, that the position of the coal-measures is among the beds immediately underneath the ferruginous sandstone (A).

If we look boyond this province we shall find this view amply confirmed. The account given by Dr. Walker* of the discovery of fragments of coal at Kota, in the Nizam's dominions, would lead to the belief that the carbonaccous and bituminous shales which he noticed were above the highest bed of argillaceous limestone. But whether this may have been the case or not is of little consequence, as all I contend for is that they are near the base of the iron-banded saudstone —a position which must at once be assigned them when we take into account their relation to the surrounding hills at Kotá, Tho success sion at Duntimnapilly, t according to the same writer, seems to have been,—anthracito, carbonaceous sandstono, and micaccous sandstono. What the rock, 15 foot thick, above the anthracite was, he does not mention. But it is worthy of remark that the carbonaceous and micacoous sandstone, into which the anthracite passes downwards, hour a great resemblance to the strata underlying the coal-soum at Barkei, and appear to coincide with the eight foot of laminated sandstone montioned by the late Dr. T. L. Boll in his detailed description of the rocks bered through at Kotá. It is to this lamonted officer that we owe the host materials for comparing the coal-measures on the banks of the Primitita with those in the north of Nagpur. The section with which he has furnished us is—sandstone (iron-banded), from 50 to 500 feet; argillaceous limestone, 9 feet; bituminous shale, three-quarters of an inch; then argillaccous limestone, bituminous shale, and limestone again, which passes into the laminated sandstone alluded to above. Without quoting further from this list of strata, which has already been published in the Journals of the Society, I may mention that the hiluminous shale at Kota, though to a considerable extent interstrutified with

Bon. Asiat. Soc. Journ., vol. x., p. 312.

[†] Quart. Journ. Gool. Soc., vol. x., p. 374, and note.

[#] Beng. Asiat. Soc. Journ., vol. x., p. 344.

Quart. Journ. Gool. Soc., vol. viii., p. 231; vol. ix., p. 351; and vol. x , p. 371.

argillaceous limestone, &c., is found only in the upper half, while argillaceous shales and limestone prependerate in the lower half. Limestone, according to the most recent information received from Dr. Bell, was the lowest rock reached after passing through 27 feet of red clay-shale.

Again, at Palamow, the first beds that Mr. Homfray* came upon under a mass of sandstone 150 to 200 feet thick were shale and coal, resting upon 30 feet of sandstone, in which we may again trace a similarity to the coal-field at Barkoi. Such also is the order of the strata at Singra, as given by Mr. Homfray. Mr. Carter, in his admirable "Summary of the Geology of India,"† shows that Jacquement found small layers of anthracite between the strata of compact limestone which immediately underlie the Panná sandstone. According to Franklin,‡ in all the glens connected with the Panná range, particularly in that of the Bagin river, black bituminous shale crops out from beneath the sandstone. Mr. Osborne's observations prove that under the sandstone of Umla Ghát there is shale with exudations of petroleum, which is succeeded below by alternate beds of sandstone and shale, limestone lying under all.

Thus we see that south and north-cast of this territory, as well as within its limits, the carbonaceous and bituminous shales may be said immediately to underlie the ferruginous sandstone. It is difficult to comprehend the Burdwan coal-field in our comparison, for it seems to lie in a basin, and the carboniferous strata rise to the surface without any superincumbent sandstone. But the connection, which cannot be established lithologically, may be rendered very manifest by the evidence of fossils. Species of Trizygia, Vertebraria, Glossopteris, and Pecopteris are common to the shales of Bardwan and those of the Mahadewas. And, although Dr. M'Clelland has professedly figured no Phyllotheca, or Calamite as he would name it, from Bengal, yet there can be little doubt that what he calls Poacites minor is identical, wanting the joint, with one of our Phyllothecas found both at the Mahadewas and Kampti, and specifically distinguished by the possession of eight sulci.

I am not certain, though I am disposed to think, that the Poucites muricata¶ of the same author is the unfurrowed stem, with nearly

Beng. Asiat. Soc. Journ., vol. x., p. 374.

⁺ Bomb. Br. Royal Asiat. Soc. Journ, No. 19, p. 204.

[#] Asiat. Ros., vol. zviii, part. i., p 103.

Beng. Asiat. Soc. Jonn., vol. vii, p. 848.

^{||} Geol. Survey, tab. xvii., fig. 4, with the description at p. 55.

[¶] Gool. Survey, tab. xiv, fig. 6.

opposite leaf-sears, described above, p. 295, as common in the shale of Barkoi, and the laminated sandstone of Silowádá. The breadth and rigid appearance of our specimen are exactly the same as in M'Clelland's figure, and there is occasionally on them a fine lengitudinal struction, which might be taken for the venation of an endogenous leaf.

Subjoined is the succession, from above, of our Indian freshwaterf collitic formation, according to the view taken in this paper.

I. Upper Sandstone Series; called by Mr. Carter the "Panna [Punna] Sandstone."

In general, coarse and thick-bedded, sometimes friable, and white, variegated with red blotches; at other times hard and of rusty colour, traversed by iron bands. Contains a few stems of trees about the base. Thickness at Nágpur 25 feet; at the Mahádewa hills upwards of 2,000 feet.

- II. Laminated Series; the same as Mr. Carter's " Kattra Shales."
- 1. Either arenaceous, carbonaceous, or bituminous. The arenaceous strata more or less mixed with clay and mica; laminated and abounding in fessils above, and gradually becoming coarser, thicker-bedded, and more destitute of organic remains below. The carbonaceous or bituminous shales are the equivalents of the laminated fessiliferous sandstone just mentioned. Though occasionally alternating with argillaceous limestone, they for the most part pass into micaceous or coarse sandstone. Thickness from 300 feet in the Nágpur territory to 2,000 feet in Bengal.
- 2. Argillaceous shales, groon, red, blue, and more rarely white, in some localities alternating with argillaceous limestone. Contains the traces of reptiles and worms. Thickness about Nagpur 80 feet, though much greater in the Bandárá district, to the east.
- 3. Limestone, sometimes compact, but often crystalline, and dolomitic. Near Nágpur 100 foot, at Mudalaity 310 foot thick.

From the above arrangement of the laminated series it will be seen there is a difficulty in disposing of the limestone. Bods of it in some districts of India alternate with our No. 2, and even with No. 1. At Mudalaity, where the latter appears to be wanting, the whole mass of it is said to everlie the argillaceous shales. I have followed the order as it is within this territory, where the limestone is most frequently crystalline, while the red shale, lying above it, has suffered no change from heat. This I am disposed to consider the typical order of succession among our "Freshwater Oölites." At Kotá, though the calcareous and

bituminous beds are interstratified to a cortain extent, yet the greater part of the latter are found above, and of the former below. Newbold, who gives us the superposition at Mudalaity, embodies his views of the order of stratification throughout Southern India in these words:—"The limestone occupies, with few exceptions, the lowest position in the sections afforded by the great lines of drainage of these tracts, and in places where the superincumbent strata have been stripped off. Next in order of superposition come calcareous shales, mingled with much argillaceous matter, then argillaceous shales and slates, sandstone, siliceous and arenaceous schists, quartzose rock, and sandstone conglomerate."* In some parts of Bundlekhand the limestone occupies a high position: but, as we have had occasion to notice before, at Bagin the bituminous shale lies above the greater part of it. In the coalfields of Bengal calcareous strata appear to be wholly wanting.

To complete the catalogue of our Indiant Jurassic Formation, I might here add—
III. Lower Sandstone Series.

This is developed at Mudalaity and in Bundlekhand, and has received from Mr. Cartor the name of the "Tárá sandstone;" but as it does not occur within our area, except perhaps in the form of gneiss, mica schist, and other metamorphic rocks, underlying our crystallised limestone, I forbear to enter on the consideration of it at present.

^{*} Roy. Asiat. Soc. Jour., vol. viii., p. 100.

[†] In the beginning of 1853, when I first published my sent iments on the sandstone and associated strata of Nagnur, I was under the impression that they were all related conformably to each other; and hence, though I made a distinction between the thick-bodded sandstone above and the plant-bearing argillaceous sandstone beneath, and again between the latter and the underlying shales, and though I showed that plutonic agency had been at work in the intervals between some of these, yet it did not occur to me to doubt that both the highest and the lowest were of the same general age as the intermediate strata. I have since learned, from Mr. A. Schlagintweit, that the sandstone and inferior shales of Southern India are unconformable; and more recently I have been informed by Professor Oldham that there is a considerable difference in inclination among the rocks of the Kattak coal-field, and especially between those corresponding to our upper sandstone and our argillaceous and carbonaceous beds. As this information could scarcoly have been elicited from the appearances presented by the rocks of Contral India, it is with gratitude that I hail the light arising from other quarters. But it now becomes a duty to inquire how for this discovery modifies the arrangement proposed for our strata three years ago. To me it appears its effect is not great.

It is to be borne in mind that the period when the rocks under consideration were deposited was just the period when plutonic action was most frequent. If granite disturbed our plant-beds before the deposition on them of the upper sandstone, we know that it also intruded on the latter strate, showing that they were in existence before plutonic agency had spent its force, and that probably the interval which elapsed between the two cruptions was not so great as to admit of a change of formation.

But there is evidence perhaps more direct. Our upper sandstone is unquestionably the same as that which is found on the banks of the Pranhité and Godávari. New it was in the conglomerate or highest part of this sandstone that the late Dr. T. L. Boll discovered his reptilian remains, which Professor Owen believed to agree best with the structure of the Teleosaurus and Amphicolian Crocodiles,—animals which generally occur in the Jurassic formation.

With regard to the age of the underlying fessiliferous rooks, Ladhere to the view which I have always entertained, since I discovered in them the first of our large asserment of ancient organisms. True, the majority of those are vegetable remains; but I was not why their evidence on that account is to be slighted, provided the specimens are entire and present the parts on which a correct classification may be founded. Are not plants characteristic of climate in their distribution over the earth's surface, as well as animals? And are not the former characteristic of cras in their range through the earth's crust, as well as the latter? I admit that the ancient Flora has lost many characters which aid in the classification of existing species; but so has the ancient Fanna. I acknowledge, in reference to Ferns, whose essential parts are perhaps best capable of preservation, that some genera have existed through many goological changes; but the same objection may be brought with greater force against some kinds of marine shells. In these and other respects I can perceive little or no difference in value between the evidence of vegetable and animal remains if only equal caution is used in both cases in their classification. Now those of our plants whose congeners have been described before, though not examined in the most favourable circumstances for accuracy, will be found, I believe, upon the whole, to be correctly named. The doubt does not occur here, but at a more advanced stage of the inquiry. It is not that our specimens assigned to the genera Glossopteris and Tanaphere, Vertebraria and Phyllotheca, may turn out not to belong to those genera; but, admitting that there has been no mistake in the identification, it is still held to be problematical what conclusion is to be drawn from the occurrence of such kinds of plants in the works of Central India. To these questions I have, in the preceding papers, attempted a reply. I may be permitted to add a few remarks on the evidence from our ancient Fanna.

To render this testimony available, it is necessary to point out the relation between the argillaceous sandstone of Kampli with its carbonaceous equivalent at the Mahadewas, which have afforded chicfly plants, and the fissile strata of Mangali with the bituminaus shales of Kota, which have furnished principally animal organisms. Now the succession of upper thick-bedded and under thin-bedded strata is the same at all these places, and favours the presumption that the rocks at all are identical. Then, the existence of hitumineus hads at Kotá, the site of ichthyolites, as well as at the Mahadewas and other localities for our vegetable remains, increases the evidence for the identity of the stratu at those places and also at Mangali, where, though there is no trace of coal, the character of the lish-scules sug gests the connection with Kotá. That the forns, which are so common in the argillaceous sandstone of Silowada, have not yet been found at Mangali is no great difficulty when it is borne in mind how limited have been the investigations in the latter strata, and when it is remembered that, while most of the quarries even in the former abound in forms, one is entirely destitute of thom, though it is remarkable for the variety of its Cossil stems. And although the Mangali fossil bods cannot, as regards fossils, be directly compared with the fern-bearing ones in the vicinity of Nagpur, yet, as has been suggested at p. 377, they may be mediately compared through the earhoniferous formation of Virginia, which contains in itself, in the closest combination, the fessils of both these localities, proving that in America at least they existed together. It is to be wished that the nature of the terrestrial vegetation which has left its impressions on the Lapidelus slabs of Keth were muniparticularly defined, for then we might discover in it some common term for estimation the contemporaneousness of the rocks with those in this province. As it is, however, I think an object for comparison may be conjectured. A few fact under the ichthychte strata at Kota there lies laminated sandstone, from which Dr. Bell procured leaves which

he was disposed to consider dicetyledonous. Now, as hitherto no true leaves of exogenous plants have been described from strata so low as the Lias or Colite, it may be allowed me to suggest that the vegetable impressions in question, presenting, as they must have done, a well-defined and entire outline, and at the same time a distinct reticulate venation, were probably not leaves, but the anostomosing and simple fronds of some species of Glossopteris. Taking the whole of these circumstances into account, I conceive myself warranted in concluding that the strata immediately underlying the thick-bedded, sandstone in the three places referred to have all been deposited at the same period.

And now we are in a position to make use of the evidence from animal remains. In the Kotá fissile strata all the ichthyolites which have been found have homocoreal tails, and on the authority of Sir P. Egerton belong to Liassic or Oblitic genera. Again, in the Mangali argillaceous sandstone not only do our Estherice resemble those of the Virginian Oulito, and our scattored fish-scales exurine such as occur in Jurassic strata, but even the Brachyops, which at first sight is apt to puzzle, is, as I have endoavoured to show, a Mesozoic form of Labyrinthodont. As it is in the Keuper of Wurtemberg that we most with the most nearly allied genus, it is surely easier to refer our Mangali reptile to the Lies, which in Europe immediately overlies the Kouper, than to carry it into the more distant Permian over the line separating Mesozoïc from Palæozoïc organisms. The red shale at Korhádi, by its position under the plant-beds, when compared with the clayey strata found in similar circumstances at Kotá, affords additional proof, if any were wanting, of the identity of the superior fissile beds at both places. But by its animal remains it also strengthens the evidence which I have given above of the Jurassic age of the whole series. Tracks of Annelids seem to be rare in ancient formations. Many of the so-called specimons are now reckoned Cololites of fishes. The marks of well-ascertained genera, of the shape and habits of the earthworm, apparently occur first in the Lower Jura rocks, and as the traces on the Korhádi shale most nearly resemble those of that familiar Annelid, we may legitimately infer that the formation in which they are met with is Jurassic.

Combining the different parts of this evidence from animal remains, we perceive that the Lies or Colite is the age for our laminated sandstones and bituminous or carbonaceous shales, which is pointed out by all with the exception of Brachyops, which, however, is altogether in favour of a Mesezoic epoch. No countenance whatever can I find in our ancient Fauna to the view that any of the strate in question are contemporaneous with the Permian or carboniferous system.

Here we might conclude had we not to encounter a difficulty from Australia. In that land of natural paradoxes it appears from the statements of the most competent witnesses that plants which occur in Indian rocks with animals of Mesozoic forms have been imbedded with animals of Palmozoic affinitios. Whether, then, as it has been forcibly put to me by Professor Oldham, are we to hold that certain Palmozoic organisms survived to Mesozoic times in Australia, or that certain Mesozoic organisms began there and here as early as Palmozoic times? After the best consideration that I have been able to give this question, I have been led to accept the former alternative. It is not, however, on account of the fact that the fossils discovered in such ambiguous circumstances belong exclusively to the vegetable kingdom; for I believe that their evidence is not to be disregarded, any more than that of animals. No, it is because I have endoavoured to allow full effect to their testimony, and to appreciate the value of their conflicting teachings, that I have arrived at the conclusion that, even without taking our animal remains into account at all, but on the authority of our old-world plants alone, the rocks under discussion ought to be looked on as Jurassic.

For what are the plants which from their being discovered in the Australian coal-field have come to be viewed of such doubtful age when found in our Indian strata? They are (I quote from memory), Sphenopteris, Pecopteris, Glossopteris, Vertebraria, and Phyllotheca. Of these the first two number species in the Oölite of Europe most nearly resembling those in the beds of Australia. And the last, though hitherto not recognised as Phyllotheca.

occurs, I have hit led mbe, in the Jurassia coal of Virginia as well as in the carbonacouns strata of New South Wiles. These three genera, then, are to be disposed of by simply letting that tostimony in the West neutralise their evidence at the Antipodes. Only two genera, if I am not mistaken, now remain, viz., Glossopteris and Fortebrara, which have not been discovered in Europe or America, but are peculiar to India and Australia. Those, as met with in this country, in the absence of proof to the contrary, we shall, on the ground of their association in New South Wales, in the mean time presume to be in favour of the Palcozoro age of their imbedding strata. But, to set over against them, we have a proponderance of acknowledge, and characteristic Jurassic genera, found not in a basin whose relations have yet to be ascertained, like that of Newcastle and Hawkesbury, in the southern homisphere, but in the Odlite of England, having the Palauzoic rocks beneath, and forming part of the most complete geological series in the world. There is first the Teniopteris of Kampti, Rajmahal, and the Dainda, in which wesco the connection with the slate of Stonefield, as we do again in the seed-vessels of this province; then there is the disc-bearing asterophyllites, or whatever it may be called, of Silowada, which is searcely distinguishable, from that at Scarborough; and lastly there are the Cycadacea of the two Bengal sites, which suggest the relation with the two English localities. When all this amount of evidence is compared with that of the two genera specified above, I think it will be admitted that even confining our view to vegetable remains, the probability is greatly on the side of a Jurassic age.

But when to this we add the testimony of the animal remains, which, as I have shown before, is all in favour of a Mesozoic epoch, it appears to me that little doubt will remain of the correctness of the view which in 1853 I advocated regarding the age of our argillaceous sandstone and its equivalent the Indian coal.

I may only add that, if we are bound to sunt up for the Jurassic age of those strata, it is easy to perceive how even one of the two genera of plants that were presumed to bear evidence on the other side, though, I believe, unknown in the Mesozofe formation of the West, does nevertheless when ranged with all the other simple frouded forms which we discover in our Indian rocks, and which out of India numerically culminate in the Oblite, admirably harmonise with this conclusion. And deducting Glossopteris, with its many species, from the Palsozofe side of the question, and adding it to the other, there will be left the single Vertebraria, with its solitary species, of which we can give no explanation on the hypothesis that the rocks which we have been considering belong to the Lias or lower Oblites.—S. II.

Nagpur, August, 1856.

